Impacts of participatory crop improvement in the low-altitude regions of Nepal

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EXECUTIVE SUMMARY

- As many poor people live in the Terai region of Nepal as in the rest of the country — the Terai has half of the country's population and is no more developed. Fifteen of the 20 terai districts are much poorer than average but grow half of Nepal's rice and have a third of Nepal's population.

- Most farmers in the Terai and low hills are resource-poor, food-deficit smallholders having less than 1 ha of land. Farmers in these areas rely on rice, and improvements in yield and quality have considerable benefits for their livelihoods. They grow rice in rainfed, low-fertility fields and these farmers have had limited, or no, access to new varieties.

- Participatory rice improvement in Nepal has been carried out by a network of partners (LI-BIRD; CAZS, UK; Department of Agriculture; NARC; and several NGOs). The project has created new varieties using client-oriented methods that involve both women and men.

- Most of the new varieties are adapted to rainfed, low-fertility fields, and because they are more disease and pest resistant need less, or no, environmentally damaging pesticides. Overall, rice varietal biodiversity is increased and other innovations introduced by the project, such as kidney bean, has increased crop diversity. The new rice varieties have improved grain quality so they can fetch a significantly higher market price (up to 25% more). They have combinations of improved drought tolerance, lower production costs, earlier maturity, and yield up to 50% more grain.

- These varieties are spreading rapidly from farmer-to-farmer in all 20 districts of the Terai and most of the low-hill districts bordering the Terai, aided by participatory extension by a network of Department of Agriculture Offices and NGOs.

- They are also performing extremely well in Bangladesh in the High Barind Tract, and in droughted conditions in the poorest, rice-growing states of eastern India.

- The impacts of the project are already considerable. Tens of thousands of farming households have adopted project varieties and benefited from them.

- Projections indicate very significant benefits with high net present values (£10 million by 2010 for Nepal) and high internal rates of return (83% by 2010).

- Institutional impacts in Nepal have also been considerable. The Department of Agricultural has now adopted project-introduced participatory methods as a means of extension and NARC is an active partner in the PPB programme. Institutional impacts are not restricted to rice, but have influenced programmes in maize and wheat.

- The project, in the long term, will have great impact outside of Nepal as international and national research systems adopt the methods developed by the project. PPB methods greatly enhance the returns to investment in plant breeding by saving as much as 10 years in bringing a new variety to farmers' fields.

INTRODUCTION

We have assessed the impacts of several research projects carried out in Nepal on participatory crop improvement (PCI) in improved agronomy, and new varieties, crops, and multipurpose trees[†]. Only the outputs pertaining to the adoption of new varieties of rice are considered here because rice is the crop where there has been the highest overall impact from project interventions. However, the impacts of other project outputs are also considerable (see Supplement 1).

In the research on rice in these projects, participatory methods for improving farmers' varietal portfolios were employed — participatory varietal selection (PVS) and participatory plant breeding (PPB) [Annex 1]. PVS tests pre-existing varieties with farmers, while PPB creates new varieties in breeding programmes carried out by plant breeders and farmers working in partnership.

A major limitation of PVS is that a suitable pre-existing variety may not exist. PPB overcomes this limitation by creating new varieties. However, PVS is more rapid than PPB. Nonetheless, PPB is still considerably faster than conventional breeding; varieties reach farmers years earlier than in a conventional system.

Both methods are designed to increase varietal diversity and to give farmers access to new varieties that better meet their needs. The PPB programmes use locally adapted varieties (landraces or introductions) as parents to build on local biodiversity. Farmers' knowledge and skills are incorporated into the breeding process to create a diverse range of varieties suited to local needs.

Institutional impacts of the projects are not reported in detail. These institutional impacts (e.g., the Nepal Department of Agriculture has adopted project-introduced participatory approaches to extension) will be the subject of another report (Stephen Biggs, in preparation). In addition, more efficient breeding methods developed by the project, if more widely applied, will have extremely large benefits but these have not been estimated in this report.

The impact of these projects is examined in detail for Nepal, but their wider impact outside of this country is first considered. For Nepal, the report concentrates on the impact of the germplasm on providing benefits to farmers. Other benefits, such as increased varietal biodiversity are also examined.

[†] Plant Sciences Research Programme (PSP) funded projects in Nepal, the earliest of which commenced in 1997. These projects were executed by LI-BIRD and CAZS in partnership with Department of Agriculture's District Agriculture Development Offices (DADOs), the Nepal Agricultural Research Council (NARC) and several NGOs such as CARE, FORWARD, REGARDS and PLAN.

THE WIDER IMPACTS OUTSIDE OF NEPAL

Wider impacts of these projects are of two types — the spread of the methods to other breeding programmes and the spread of the rice varieties bred in the PPB programme to countries outside of Nepal. The wider impacts of the PTD projects outside of Nepal may well be larger than their impact within Nepal although, overall, they will be more difficult to measure.

The Impact of Methods Outside of Nepal

The PPB methods employed:

- Greatly increase the speed of adoption of varieties (saving at least 7 years) and hence increase the benefits from the research.
- Enhance varietal biodiversity using locally adapted germplasm.
- Greatly enhance the cost-effectiveness of the breeding programme by simple changes in breeding methods, such as testing for grain quality before yield testing.
- Are very cost effective because of the low cross number, high population size breeding strategy employed in the PPB.
- Greatly enhance the efficiency of selection in difficult environments by farmers selecting in bulks in their own fields.

These results from Nepal will be more influential because they are strengthened by results in other DFID-PSP-funded projects in India that confirm the benefits of collaborative breeding.

The importance of early testing for grain quality before yield trials take place is a good example of the project outputs relating to participatory methods. The projects have developed simple methods for the participatory evaluation of organoleptic quality. It is cheaper to discard a variety because it has a poor taste, or poor milling quality than to test it in multilocational yield trials. This simple change can render plant breeding programmes much more efficient (Gyawali *et al*., 2002).

As more results emerge, more papers will be published and more presentations will be made in various fora on this work. Although their influence is difficult to measure, it is probable that many breeding programmes will be favourably influenced by this research, including those of IRRI, WARDA, CIMMYT and NARC.

The Impact of Germplasm Outside of Nepal

Eight PPB varieties[†] have been sent to the DFID bilateral project of the Gramin Vikas Trust (GVT) in India. These varieties were tested in medium upland and medium lowland conditions. Varieties Sugandha 1 and Judi 578 are under further trials.

[†]Sugandha 1, Judi 578, Barkhe 2001, Barkhe 2026, Barkhe 2027, Barkhe 3004, Barkhe 3009, and Barkhe 3010

PPB and PVS varieties have been sent to an NGO in Bangladesh (People's Resources Oriented Voluntary Association, B/220, Kazihata, Rajshahi, Bangladesh) where they have been grown in the main season in the Barind. Several of these varieties performed well in the main season of 2002, and because most are of early duration they will facilitate the growing of a subsequent *rabi* crop. Variety Pant 10, identified by PVS, and variety Judi 582, produced by PPB, are among the best performing varieties.

Rice varieties from the PVS and PPB programmes have been sent to China (Anhui Academy of Agricultural Sciences) where they are undergoing initial multiplication and it is planned to test a range of PPB and PVS varieties with CONCERN in Afghansistan.

Some publications from the Nepal PCI projects

Gyawali, S, Joshi, KD & Witcombe, JR. 2002. **Participatory plant breeding in rice in low altitude production systems in Nepal**. *Proceedings of a DFID Plant Sciences Research Programme / IRRI Conference, Breeding Rainfed Rice for Drought-prone environments Integrating Conventional and Participatory Plant Breeding in South and Southeast Asia*, 12-15 March 2002, IRRI, Los Baños, Laguna, Philippines. CAZS, University of Wales, Bangor.

Joshi, KD, Gyawali, S & Witcombe, JR. 2002. **Participatory scaling up of participatory varietal selection**. *Proceedings of a DFID Plant Sciences Research Programme / IRRI Conference, Breeding Rainfed Rice for Drought-prone environments Integrating Conventional and Participatory Plant Breeding in South and Southeast Asia*, 12-15 March 2002, IRRI, Los Baños, Laguna, Philippines. CAZS, University of Wales, Bangor.

Joshi, KD, Sthapit, BR, Subedi, M and Witcombe, JR. 2002. **Participatory plant breeding in rice in Nepal**. In: *Farmers, Scientists and Plant Breeding: Integrating Knowledge and Practice*, David A Cleveland & Daniela Soleri (Eds), CABI, Wallingford, UK 10:239-267.

Sthapit, B, Bajracharya, J, Subedi, A, Joshi, K, Rana, R, Khatiwada, S, Gyawali, S, Chaudhary, P, Tiwari, PL, Rijal, D, Shrestha, K, Baniya, B, Mudwari, A, Upadhaya, M, Gauchan, D and Jarvis, D. 2002. **Enhancing on-farm conservation of traditional rice varieties in situ through participatory plant breeding in three contrasting sites from Nepal**. *Proceedings of a DFID Plant Sciences Research Programme / IRRI Conference, Breeding Rainfed Rice for Drought-prone environments Integrating Conventional and Participatory Plant Breeding in South and Southeast Asia*, 12-15 March 2002, IRRI, Los Baños, Laguna, Philippines. CAZS, University of Wales, Bangor.

Poudel, D, Chaudary, P, Chowin, KR & Ghimere, H. **Case studies of seed production and marketing through farmers' groups in Nepal**. CAZS Discussion Papers No 4. CAZS, University of Wales.

Joshi, KD & Witcombe, JR. 2001. **Participatory varietal selection, food security and varietal diversity in a high potential production system in Nepal**, 267-274. *An exchange of experiences from South and South East Asia: proceedings of the international symposium on participatory plant breeding and participatory plant genetic resource enhancement*, Pokhara, Nepal, 1-5 May 2000. SWPGRA, CIAT, Cali, Colombia.

Witcombe, J.R., Joshi, K.D., Rana, R.B. & Virk, D.S. 2001. **Increasing genetic diversity by participatory varietal selection in high potential production systems in Nepal and India**. *Euphytica* 122: 575-588.

Witcombe, J.R., Subedi, M. & Joshi, K.D. 2001. **Towards a practical participatory plant breeding strategy in predominantly self- pollinated crops**, 243-248. *An exchange of experiences from South and South East Asia: proceedings of the international symposium on participatory plant breeding and participatory plant genetic resource enhancement*, Pokhara, Nepal, 1-5 May 2000. SWPGRA, CIAT, Cali, Colombia.

Witcombe, J.R. & Virk, D.S. 2001. **Number of crosses and population size for participatory and classical plant breeding**. *Euphytica* 122:451-462.

Witcombe. J.R. 2000. **The Impact of decentralized participatory plant breeding on the genetic base of crops**. In: *Broadening the Genetic Base of Crop Production* Cooper et al., (Eds) CABI, Wallingford, UK 26:407-417.

NEPAL

Introduction

We now examine the impact of these projects in Nepal. The projects operate in the most important rice growing region of Nepal - the Terai. The area of rice in the Terai as a whole, of about 1.1 to 1.2 million ha, is about 75% of the total 1.5 million ha rice area of Nepal. Rice is the most important crop to the livelihoods of farmers in the Terai. They grow it in two seasons, the early or *Chaite* season and the main or *Barkhe* season. The area under *Chaite* rice (110,000 ha) is about one tenth of the main season area.

First we look at the socio-economic situation regarding rice improvement in the Terai, and then we examine the impact of the PPB programme. The outputs are described and then the impacts are described from surveys, interviews and a financial analysis.

Livelihoods and poverty in the Terai

Given the great importance of rice in the Terai, will increases in productivity benefit the poor? We examine how many poor people live in the Terai and the extent to which they depend on rice for their livelihoods.

Human development in the Terai

The UN has compiled a poverty and deprivation index for all of the districts of Nepal (Supplement 3). The average index for Nepal and for the Terai as a whole is 0.47 (on a scale of 0 for least developed to 1 for most developed). This overall average development in the Terai is only because a few districts are highly developed (Fig. 1). Of the 20 Terai districts, 14 are average, or below average, in development. Rautahat, the poorest district in the Terai has a population of over 500,000 and is the fourth poorest district in Nepal. Several population groups in the Terai, including the Tharus and Musahars, have been disadvantaged for generations and remain so. Moreover, the improvement in the human development index from 1996 to 2000 in the Terai as a whole (12.1%) was lower than in the hills (17.5%).

For the two project districts, one is below average (Nawalparasi) and the other (Chitwan) is better off.

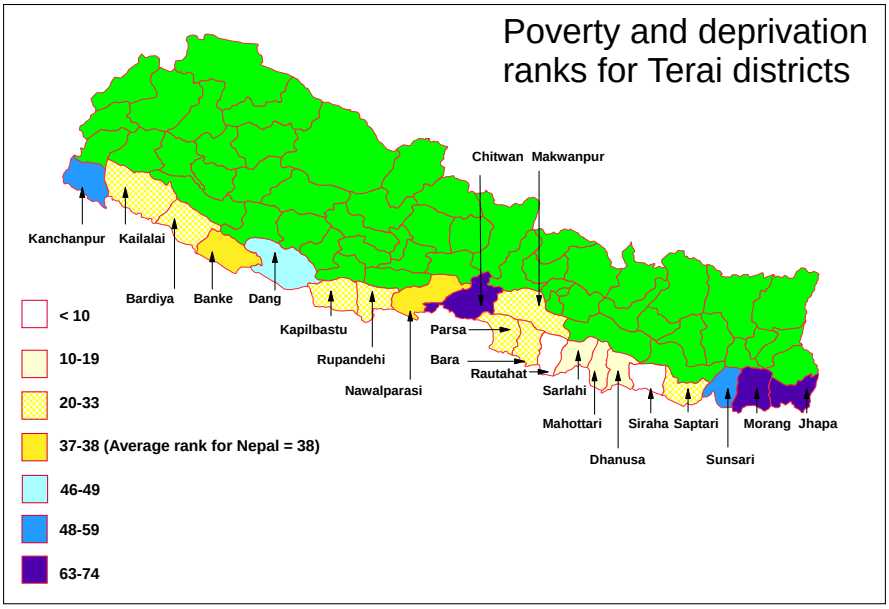

***Figure 1*. Poverty and deprivation index ranks (1 = least developed district, 75 = most developed district) for the Terai districts, 2001.**

Food self sufficiency

The UN does not provide data on food self sufficiency but project baseline data were obtained for households in eight villages in Chitwan and Nawalparasi. Despite the relatively high degree of development in these two districts, the majority of farmers in the 8 studied villages were food deficit (Fig. 2).

From interviews with key participants, the landholding of food-deficit farmers is very low, and is usually characterised as less than 0.5 ha (Supplement 4). Food balance farmers have about 1 ha of land, but this varies from village to village depending on the productivity (largely determined by the availability of irrigation water) of the village rice fields.

The key informants commonly mentioned the importance of off-farm income as a determinant of the wealth ranking of households. Nonetheless, rice production is important to people's livelihoods and increased production provides more opportunities for earning income from labour since harvesting and threshing are predominantly manual operations in the Terai.

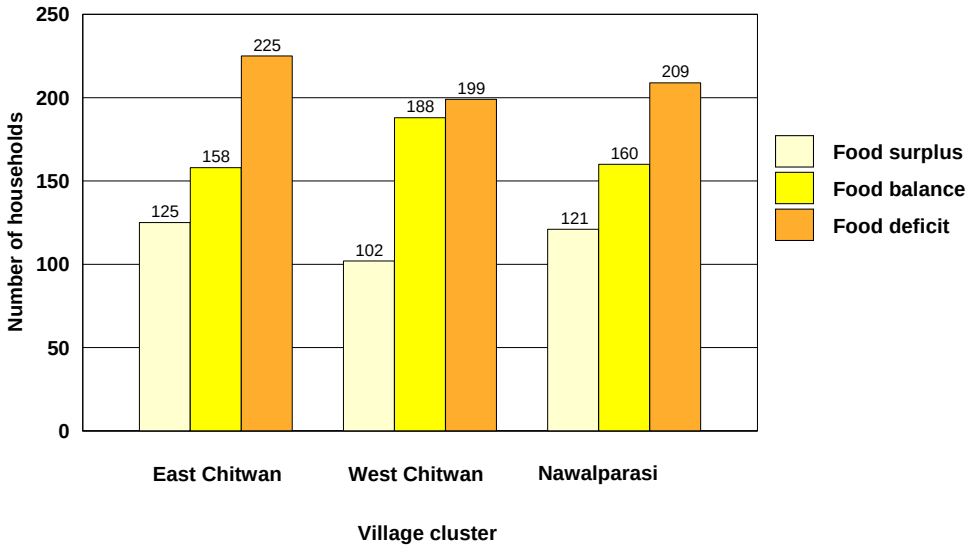

Figure 2. **Distribution of households according to whether they are food-deficit, food balance, or food surplus. Two villages from east Chitwan cluster, 3 villages from west Chitwan cluster, and 3 villages from Nawalparasi cluster.**

Less favourable environments for rice cultivation

Although the projects were initially designed to test PTD in high-potential production systems much of the project area is less favourable for agriculture. Rice is grown under rainfed conditions or with only limited quantities of irrigation water. It is estimated that about 70% of the main-season rice in the Terai is grown under rainfed and limited irrigation water conditions (Fig. 3 and Supplement 2).

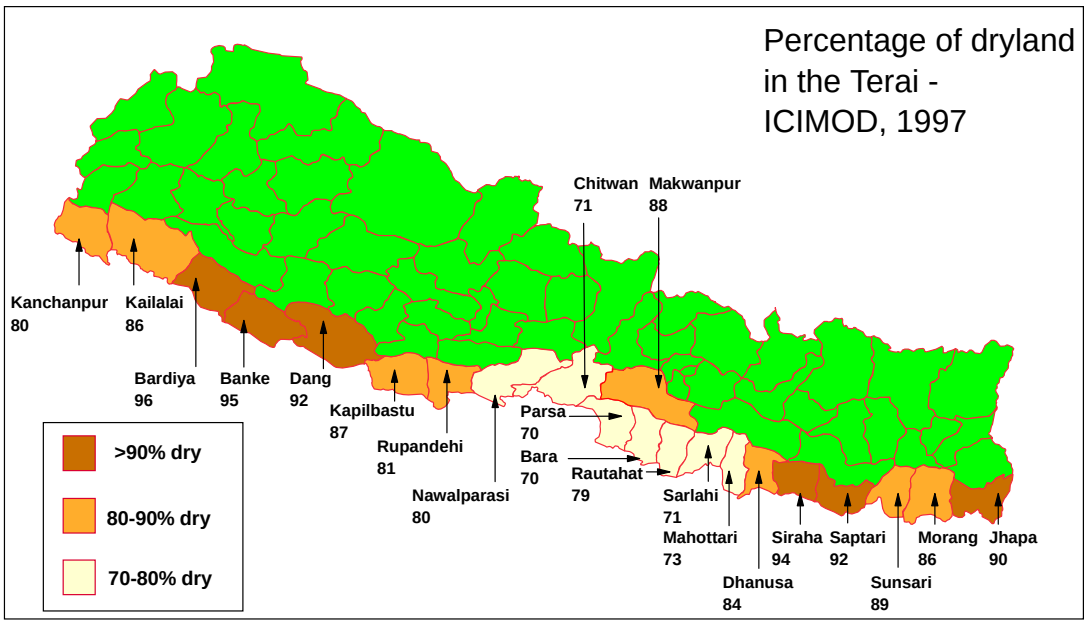

Figure 3. **Percentage of land that is without perennial irrigation according to ICIMOD, 1997.**

Constraints

Farmers grow few and old varieties

Participatory surveys, in the project villages of Chitwan and Nawalparasi, revealed that farmers were growing old varieties in both rice-growing seasons, sometimes as much as 40 years old (Witcombe *et al*., 2001). The varietal diversity was often extremely low with the most popular variety occupying the majority - sometimes over 90% - of the area (Fig. 4).

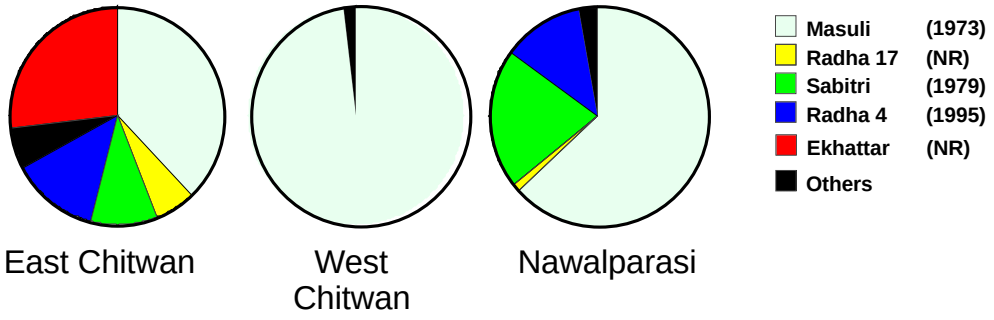

Figure 4. **Area under main-season rice varieties in three village clusters of East Chitwan, West Chitwan and Nawalparasi, 1997. (Year of release of variety in parentheses; NR = not released).**

The National Programme has released relatively few varieties for the Terai (Supplement 5) particularly in view of its importance in area, and the rate of release for the Terai has declined in recent years. Moreover, a minority of the varieties that have been released have been popular with farmers. Instead, many of the most popular varieties, such as Sarju 52 in the west of the country, are farmers' introductions, most of which are from India. Others are varieties from the Nepalese research system that have not been officially released, such as Kanchhi Masuli[†], in the east of the country, and Ekhattar and Radha 17. Sarju 52 and Kanchhi Masuli are two of the most popular varieties in the Terai and have spread entirely from farmer-to-farmer, without official support.

[†]Kanchi Masuli was originally from India and also known by Nepalese farmers as Jhapali Masuli, Aus Masuli, Banspate, and Bans dhan. Ekhattar and Radha 17 were tested for several years by NARC in yield trials and in farmers' fields while Kanchhi Masuli was tested in yield trials. None of them were released.

PROJECT OUTPUTS

Varietal choice has now increased

One of the main achievements of the PTD projects in Nepal has been the identification of an increasing number of rice varieties (Fig. 5), from both PVS and PPB, that farmers wish to adopt. More recently, these new varieties are mostly the products from the PPB programme (Annex 2).

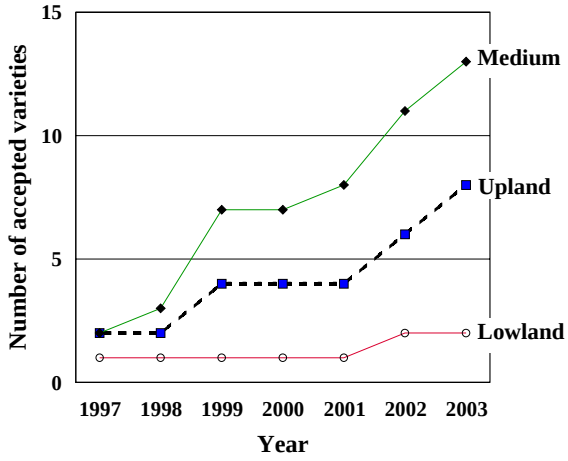

Figure 5. **Increase in available varietal choice for the main season from the project activities for farmers in the Nepal Terai. The increase in available diversity will be higher still in 2004.**

Over 15 varieties (Annex 2 and Supplement 8) suited to medium upland and upland conditions in the main season - the majority of the area in the Terai – have been identified. According to PRAs in the project area, having less productive fields is one of the indicators of a lower wealth rank. Hence, generally, it is the resource-poor farmers of the Terai that farm the uplands. Wealthier farmers have more productive land with permanent irrigation. Such land is more expensive (about twice the cost per area).

Scaling up the project outputs

After the PVS and PPB has identified or created new varieties, these are widely disseminated in activities termed by the project as ‘scaling up’. The time at which scaling up commenced has varied by district (Fig. 6, Supplement 6) and was earliest in the project districts of Chitwan and Nawalparasi.

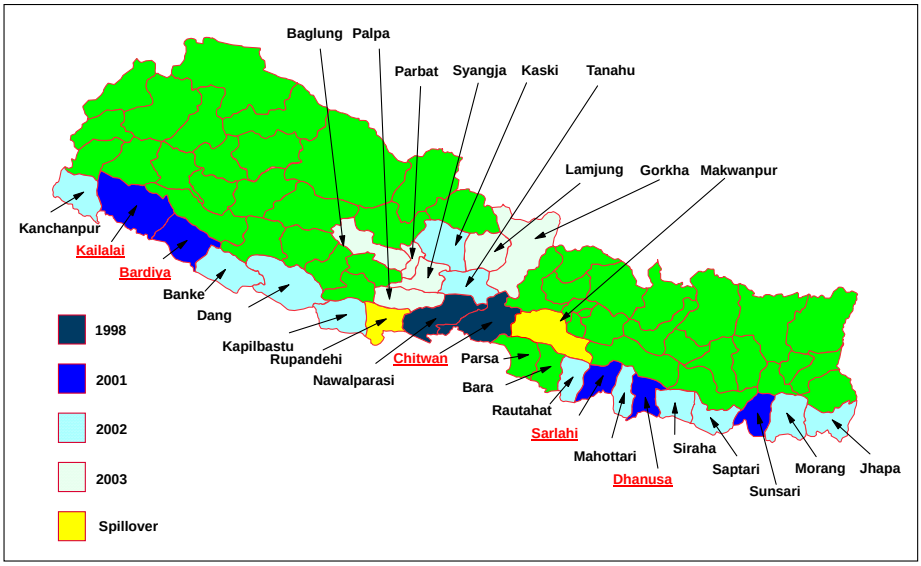

Figure 6. **Year of first scaling up activities by district, 1998-2003. Districts underlined denote that there was a letter of agreement between LI-BIRD and the Department of Agriculture in that district.**

The institutional impacts from this scaling up in Nepal have also been considerable. The Department of Agricultural has now adopted project-introduced participatory methods (i.e., Mother and Baby trials reported in Annex 1) as a means of extension and, under a Memorandum of Understanding with LI-BIRD, NARC is an active partner in the PPB programme. Institutional impacts are not restricted to rice, but have influenced programmes in maize and wheat. These institutional impacts are being considered in more detail in another report (Stephen Biggs, in preparation).

IMPACT - FARMERS' VOICES

A Case Study for Swarna Rice

Agauli village, Nawalparasi, 2002

I have been growing this variety for the last three years, and my estimation is that Swarna yields one and a half times as much as Masuli.

Masuli has to be harvested while the fields are still wet and this is very inconvenient. Swarna matures when the fields are dry and this makes harvesting much easier.

Swarna has spread in this village from 15 kg of seed [from LI-BIRD]. I got this seed from another farmer who got the seed from LI-BIRD

More or less every household in this village grows Swarna and it covers about 75% of the entire rice area of our village.

Although Masuli has a higher price than Swarna, because the yield of Swarna is higher the returns are more. It is difficult to distinguish the milled rice of Masuli and Swarna. If some miller mixes the rice [of Masuli and Swarna] and mills them together then nobody can detect the difference.

Masuli has more disease than Swarna.

Kamali and Arjun Kumar Shrestha of Agauli Village Development Committee (VDC), Sherganj village, Nawalparasi explained that they only own about one fifth of a hectare (7 *Kattha* in local units) of low-lying land where they used to grow variety Masuli. It never produced more than 0.75 t in that land - just enough to sustain the six members of their family for about six months. They heard about Swarna three years ago and first tried it in a small plot. Kamala says that, to her surprise, it did extremely well even when the field had standing water where Masuli generally does very poorly. They decided the next year to plant the entire plot to the new variety and it yielded nearly double that of Masuli (1.3 t). The household, along with the harvest from their early-season rice, had more than enough grain. They sold nearly 500 kg of Swarna and bought corrugated iron sheets for their cow shed.

In discussions with the Shrestha couple it was learnt that Swarna is now contributing to the food needs of about half of the farmers in Sherganj village.

Tek Kumari Thanet, Sherganj, also owns 7 *Kattha* of land. Like most other farmers she also grew Masuli in the past. She has been growing Swarna for the last two years. She never had enough rice to feed her family but now, because of the higher yield of Swarna, she no longer has to buy rice.

Pitmaber Chaudhary of Agauli is a food deficit farmer with only 4.5 *Kattha* of land. Masuli rice harvested in late November only lasted until about February. "*Once we started growing Swarna, we could meet all our family needs from our own harvest and do not have to buy rice*".

Sarswati and Sita Thanet of Bamnauli, Abhiyun**:** These two women live in a joint family of 15 members. They have a landholding of over 2 ha and produce surplus grain. They have been growing Swarna for the last five years. It started with a PVS trial in 1999, and now Swarna covers nearly 55% of their lowland. Although they have diverse sources of income (sale of vegetables, income from rice mill, tractor and salary from the Nepal Army) they consider that rice contributes nearly 75% of the family income. All the day-to-day family expenses, including hired labour and inputs for the farm, are met through the income from selling rice. They reckon that yield of Swarna is nearly one and a half times more than that of Masuli and that their rice sales have increased from 4 t to 6 t because of Swarna. The increased income has particularly contributed to paying for the education of children and for health care.

Dhan Kumari and Om Narayan Mahato of Agauli produces sufficient rice to feed their family. Apart from Swarna, this family has been growing a number of new rice varieties introduced in the PVS programme such as Pant Dhan 10, BG 1442 and Barkhe 1027. Before these new varieties they were growing Sabitri, which they abandoned because it was highly susceptible to zinc deficiency, difficult to thresh, and prone to pest damage. They have been growing Swarna for the last four years, one year while they were still in a joint family and three years after they became independent from it, and clearly see that Swarna yields more than Sabitri. Their net income from the new variety, this year, was at least Rs. 10,000. From the additional income from the increased sale of rice in the last three years they have paid off about Rs. 9000 of a loan. This year they spent nearly Rs. 11,000 to put corrugated iron roofing on their house and invested some money in establishing their small banana orchard. They say that their family needs have increased due to the schooling of the children and for investments in vegetable and banana farming but now they do not see any problem to meet them. "*With Sabitri, I was just meeting my family needs and it would have not been possible without Swarna to repay the loan, go for improved roofing or pay the fees of my kids!"*

Sun Maya Mahato of Agauli. She owns about 1.3 ha land and has grown Swarna for the last four years. This year the variety occupies nearly 80% of her rice area. She reckons that Swarna yields nearly 1.5 to two times more than Masuli, the variety she grew before.

"*We had to buy two new Bhakari*[1] *to store extra grain from Swarna while in the past we never bought extra Bhakari. We never sold rice while growing Masuli, as it was just enough to meet the family needs. But Swarna gave us much more cash. We repaid a Rs. 50,000 loan from the additional income from Swarna. This year, we had to spend nearly Rs. 30,000 for the maternity care for my daughter-in-law, which also came from the sale of Swarna. Had the cash not been with us, we had to sell out part of our land or borrow money at a very high interest rate. We do not have any other significant sources of income. Though, we have two fishponds, we hardly earn about Rs. 2000 from the sale of fish*".

[1] *Bhakari* is a local storage structure used for storing food grains, which may be an earthen pot or made of bamboo or wood.

IMPACT - ADOPTION AND BIODIVERSITY IN THE PROJECT DISTRICTS

Adoption in Chitwan and Nawalparasi

In Chitwan and Nawalparasi adoption of project-identified and project-bred varieties is high. Overall, across the two districts adoption of project varieties reached an estimated 13% of the total rice area in 2001 and as much as 17% in 2002[†].

As an example, the adopting households, area of adoption and benefits to farmers[‡] are given for Chitwan alone (Fig. 7).

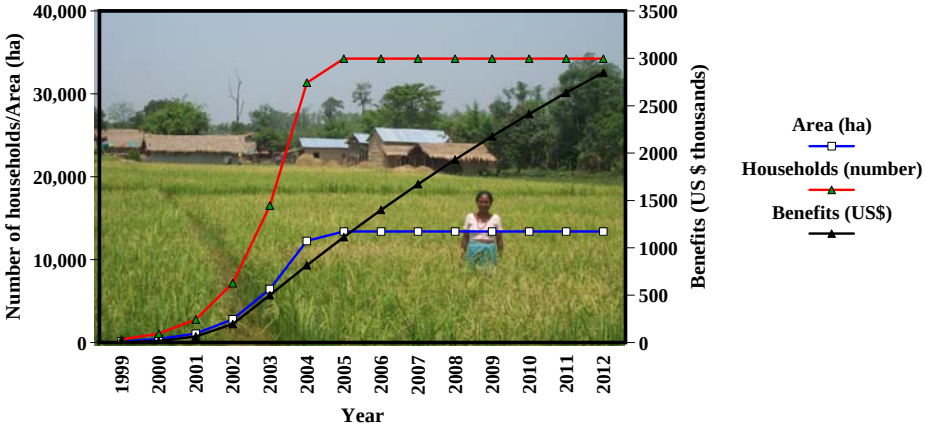

Figure 7. **The area (ha) under new rice varieties in Chitwan over time and the estimated number of households that will be growing them (assuming a maximum adoption of 40%) and the total benefits accrued to farmers (using a 5% discount rate). The woman farmer from Chitwan is standing in a field of a project variety, Barkhe 2001, that she has adopted.**

Varietal diversity

The introduction of new varieties contributed to a great increase in on-farm varietal diversity measured as varietal richness (number of varieties) in each village (Fig. 8). Varietal richness continued to increase over years. The greatest diversity was found in villages where there was higher diversity in rice growing conditions.

More varieties were found in project villages than in villages proximal to project villages or in the control villages. The increase in the number of varieties in the project villages was due to the introduction of promising PPB varieties.

Impacts on varietal diversity can easily be seen at a village level (Fig. 9).

[†] From a survey of over 3000 households in Chitwan and Nawalparasi.
[‡] For details of this analysis see the full financial analysis below.

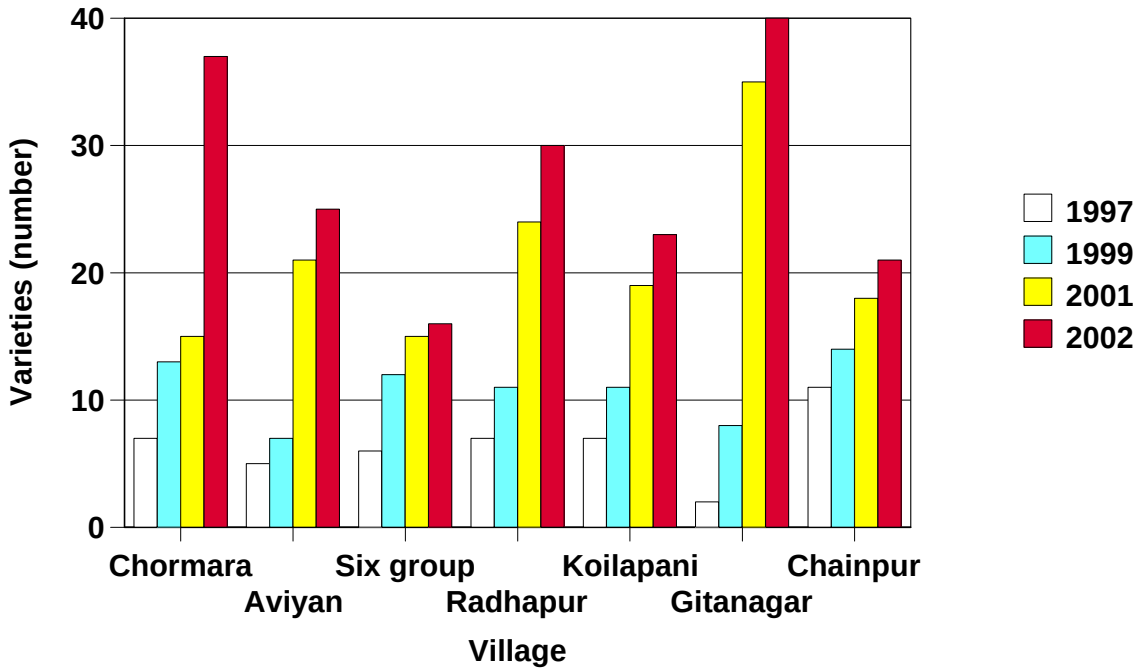

Figure 8. **Varietal diversity in rice before and after the project interventions across all project villages, 1997 to 2002.**

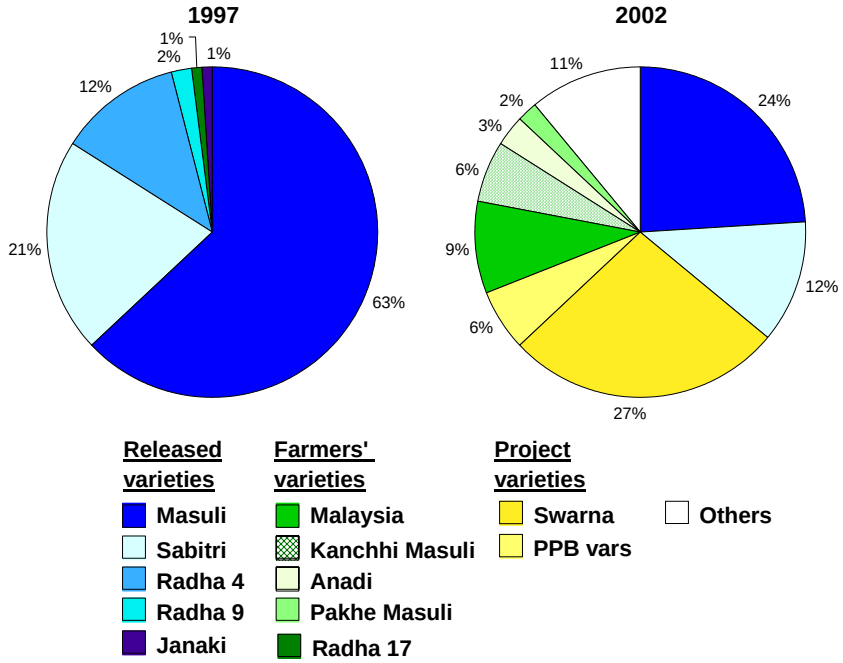

Figure 9. **An example of adoption of project varieties. Changes in varietal adoption in Nawalparasi village cluster (sample of 1637 households) from the baseline survey (1997) to the 2002 main season. By 2002, the adoption of project varieties is 33% of the total rice area in the village cluster.**

IMPACT - FINANCIAL BENEFITS

Three scenarios for estimating financial benefits of the new varieties in Nepal

Three scenarios have been examined to estimate the net present value of the new varieties identified or bred by the PTD projects in Nepal (Table 1).

All of the assumptions are supported by survey or trial data. The 2002 survey data of LI-BIRD and DADO, Chitwan, show that in many villages adoption of project varieties in Chitwan is above 40% and that adoption in the district as a whole is already in excess of 10%. Rates of spread have been measured from farmer-to-farmer for several varieties and vary, according to their popularity, from 1.5-fold to over 20-fold per annum. Recently, PPB varieties have increased on average in Chitwan (from main season 2001 to the main season of 2002) at a rate of over five-fold.

The areas of adoption were calculated for groups of districts according to the first year of project intervention. The NPVs were calculated on the total adoption across all districts.

Table 1. The three sets of assumptions employed in the financial analysis.

	Scenario		
Assumption	**Conservative**	**Realistic**	**Higher**
Spread from farmer-to-farmer per year (multiple)	2	2.5	3
Adoption ceiling (% of total rice area)	20	40	50
Benefit (£ ha^{-1})	24	33	42
Seed supplied per district†	5	7	9
Years seed supplied after first intervention	3	5	7

† As the number of ha of rice that can be transplanted from the project-supplied seed

Costs

The same cost assumptions have been assumed in all of the scenarios and are the marginal costs of undertaking the PVS and PPB programmes of LI-BIRD/CAZS.

It is assumed that the costs of NARC and DADO are part of their existing budgets and activities (rice breeding for NARC and extension for DADOs) and these funds would be spent in the absence of the project. The costs of the PVS/PPB programme are assumed to be £100,000 a year and incurred in every year for which a benefit has been calculated.

The DFID PSP-funded projects in Nepal, 1997-2005.

DFID number	Project title	Project duration	Total costs (£ '000)
R6748	PCI in high potential production systems in India and Nepal	1997-1999	£119
R7542	PCI in high potential production systems – piloting sustainable adoption of new technologies	2000-2003	£178
R7122	PPB in high potential production systems	1998-2000	£ 44
R8071	PPB in high potential production systems – an evaluation of products and methods	2001-2005	£170

As the surveys on adoption continue over the years, these estimates will be revised. The data available for adoption in 2002 are above the realistic scenario, and the amounts of project-supplied seed in 2003 were also above that of the realistic scenario.

The data for these analyses are shown in Supplement 7, and a detailed consideration of the realism of these assumptions is presented in Annex 3.

The total benefits at a 5% discount rate are substantial in all three scenarios (Fig. 8). The net present values (NPV) range from £2 to £29 million by 2010, and £4 million to £52 million by 2012. Even by 2005, the end of the current DFID RNR strategy plan, all scenarios show a positive return, with the higher scenario giving an NPV of more than £3 million. The internal rates of returns vary in 2012 from 43% to 126%. Hence the returns on this agricultural research are high, and at least as good as those for other development activities.

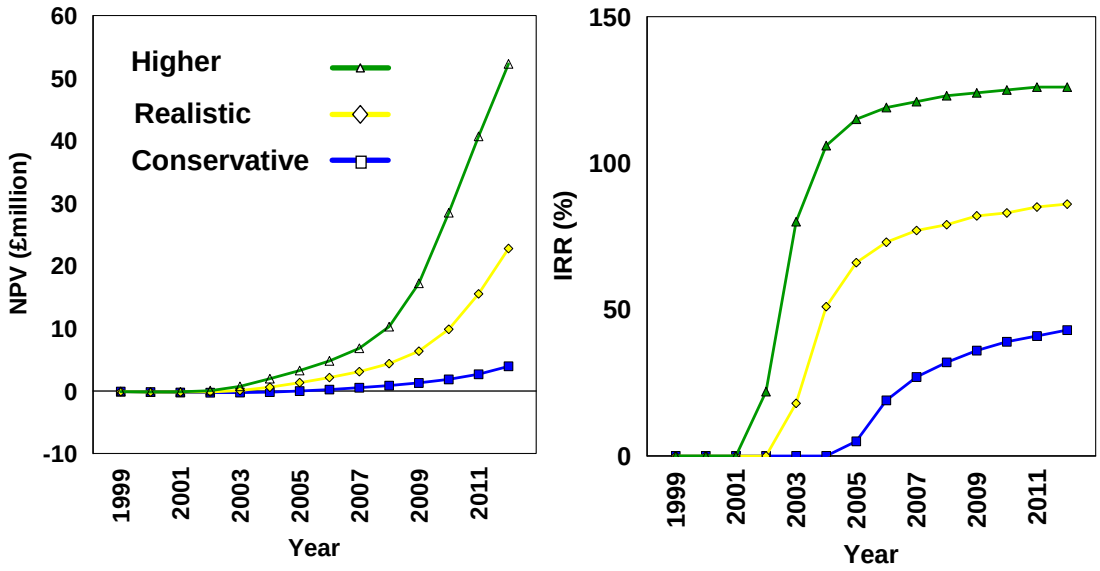

Figure 10. **The NPV and IRR over time with the 'conservative', 'realistic' and 'higher' scenarios.**

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Annex 1. PPB and PVS

A brief introduction to participatory varietal selection and participatory plant breeding

Two methods of getting improved germplasm to farmers

Many farmers grow old varieties or landraces, and hence fail to benefit from the most modern products of plant breeding. One of the main reasons for low cultivar replacement rates is that farmers have inadequate exposure to new cultivars. One way of increasing the speed of adoption of new varieties is for farmers to be given a wide range of novel cultivars to test for themselves in their own fields. The method we use is termed participatory varietal selection (PVS). A successful participatory varietal selection programme has four phases:

1. Participatory evaluation to identify farmers' needs in a cultivar;
2. A search for suitable material to test with farmers;
3. Experimentation on its acceptability in farmers' fields;
4. Wider dissemination of farmer-preferred cultivars.

The cultivars are selected carefully. To save time and ensure availability of seed we have used already-released cultivars, not only from the target region, but also from other regions or countries. The varieties are then tested with farmers in a Mother and Baby trials system. A few Mother trials are conducted in farmers' fields that have all of the new varieties. There are many more Baby trials in which all the varieties are again tested. However, any individual farmer only tests one variety by comparing its performance to the local variety in his or her fields.

However, PVS is limited to employing the existing variation among cultivars, and sometimes well-accepted cultivars cannot be found. Participatory plant breeding (PPB), in which farmers select from segregating material, is a logical extension of PVS and is desirable when the possibilities of PVS have been exhausted. In our PPB programmes we exploit the results of PVS by using identified cultivars as parents of crosses. Weaknesses in cultivars are identified in the PVS programme and they can be crossed with varieties that have complementary traits to eliminate those weaknesses. For example, one can cross a high-yielding but low-grain-quality variety with one with superior grain characteristics.

What we have found is that PVS and PPB get to be used in combination. We start with PVS and that helps to identify parents, then we carry out PPB. As soon as there are products from this PPB, we test them in PVS trials. This can be a continuous process because new varieties, whether introduced or from PPB, are always becoming available that can be tested by PVS.

PVS does not just identify better varieties

One of the great strengths of PVS is that it is an extension method as well as a research method. For example, PVS trials resulted in a dramatic spread of new varieties (Fig. 1.1). The rates of increase from one *Chaite* season to the next are 18 to 30 fold increases in the size of the harvest with similar increases in the area sown.

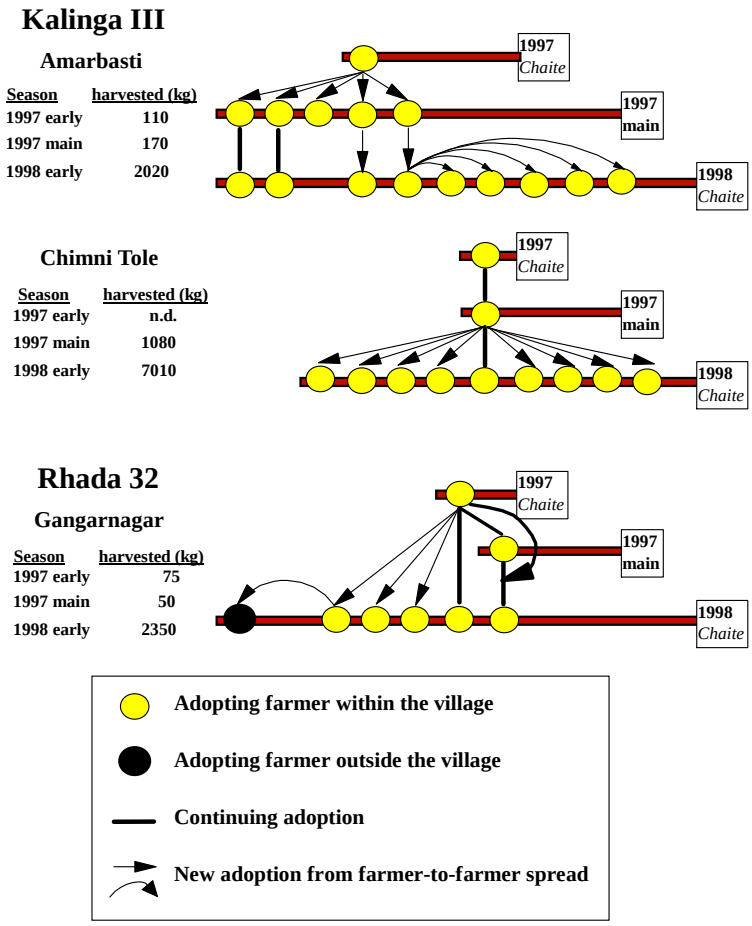


Figure 1.1. **Spread of seed of rice varieties Kalinga III and Radha 32 from farmer to farmer from one original farmer each in Amarbasti and Gangarnagar, west Chitwan; Chimni Tole, east Chitwan**

Notes: In the case of Amarbasti, two farmers, after the main season 1997, dropped the variety but passed it on to another farmer. Curved arrows in 1998 indicate spread in the same year, by distribution of seedlings. Curved arrow in Ganganagar indicates a continuing adopter grew the second crop by obtaining seed a second time.

An example of PPB methods

We have adapted PPB methods to take advantage of the strengths of breeders and farmers. The breeders produce material that is genetically homozygous but highly

heterogeneous by advancing the bulk populations[†] from the F_2 to the F_5 generations with minimal selection (Fig. 1.2). This means that we give bulks to farmers at a quite advanced generation when it is expected that there will be a good response to selection between plants[‡], and when segregation in the next generation is no longer a major complicating factor[‡].

A key element of PPB is the *collaborative* participation of farmers who grow a bulk on their own fields and select amongst it. Using this collaborative breeding, it is possible to replicate selection cost-effectively by giving seed of a particular bulk to many farmers. The selection is thus replicated across physical environments (different farmers' fields) and across farmers (who may have different selection strategies and select for different traits that best meet their needs).

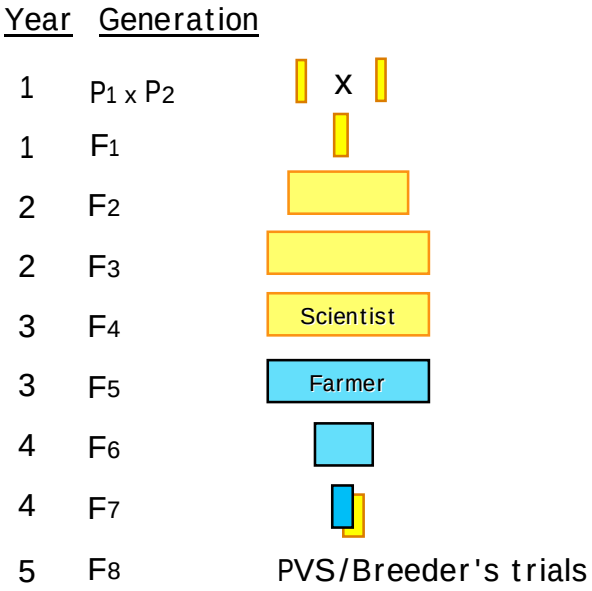


Figure 1.2 **A schematic diagram of a PPB programme. Breeders control the process until the F_4 generation, then farmers collaborate from the F_5 generation onward. Breeders include selected bulks in formal trials from the F_8 generation. It is assumed that two crops of rice are grown per year**

Giving farmers bulks to grow on their own fields is an effective strategy. Farmers are willing to select in the bulks over several generations and produce their own variety that can be phenotypically very uniform (Figs. 1.3 and 1.4).

[†] A bulk population is derived from many F_2 generation plants so that the bulk represents much of the variability generated by the cross. We often create a bulk by starting with seed from as many as 20,000 F_2 plants. Each subsequent generation is derived from many parental plants.

[‡] This is because, by the F_5, the genetic differences between plants are high (i.e. there is a high between-plant heritability). Also, because the individual plants are nearly homozygous (93.75%) all the progeny of an individual plant will tend to be alike and resemble the parent.

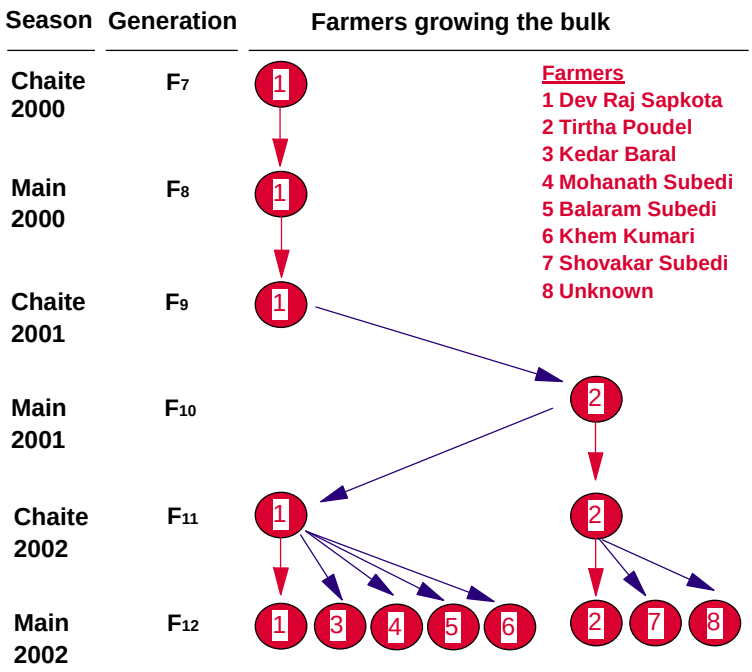
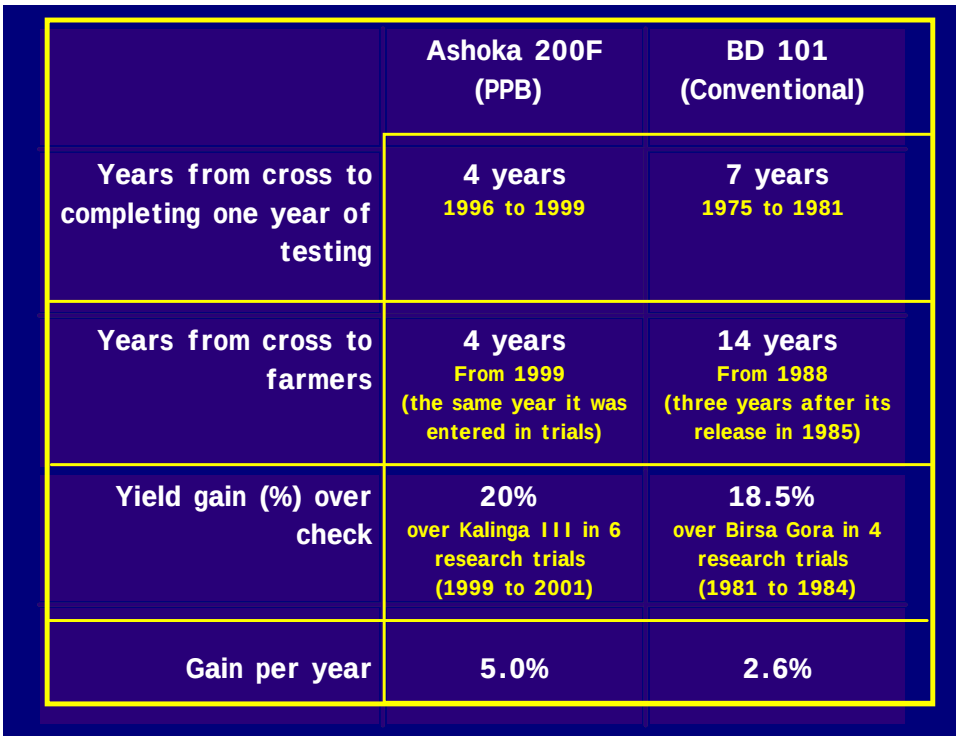


Figure 1.3. **An example of collaborative plant breeding where a farmer has grown a bulk for several years to produce variety Judi 141F. The bulk has been distributed to seven additional farmers. Red arrows continuing adoption, blue arrows farmer-to-farmer spread.**

Figure 1.4. **Farmer Dev Raj Sapkota in the main season of 2000 with CH45 (left) and the PPB bulk from which Judi 141F was derived (right)**

One great advantage of PPB is that it is much faster than conventional breeding (Fig.1.5). The economic value of this reduction in time can be very large. Pandey and Rajatasereekul (1999) showed that the economic benefit of completing a breeding cycle only two years earlier was $18 million over the useful life of a rice variety in 5 million ha in northeast Thailand. They concluded that efforts to reduce the breeding cycle by two years can have a handsome payoff, and that the economic losses

associated with a delay in official release were high. For example, a three-year delay in the official release of varieties, assuming it normally takes 13 years to complete, reduces economic benefit by about 25%.



	Ashoka 200F (PPB)	BD 101 (Conventional)
Years from cross to completing one year of testing	4 years 1996 to 1999	7 years 1975 to 1981
Years from cross to farmers	4 years From 1999 (the same year it was entered in trials)	14 years From 1988 (three years after its release in 1985)
Yield gain (%) over check	20% over Kalinga III in 6 research trials (1999 to 2001)	18.5% over Birsa Gora in 4 research trials (1981 to 1984)
Gain per year	5.0%	2.6%

***Figure 1.5*. A comparison of the breeding of rice cultivar Ashoka 228 by participatory methods and the conventional breeding of rice cultivar BD 101.**

Annex 2. Summary of promising PPB varieties

Table 1. Increasing availability of varietal choice for the Terai**. Farmer-accepted varieties for the *Chaite* season, 1997 to 2004.**

Variety†	Source (method, country)	Pedigree of PPB varieties	First year tested	First year with > 500 kg seed	Situation
BG 1442[1,2]	PVS, Nepal		1998	1999	MU, ML
Kalinga III	*PVS, India*		*1997*	*1998*	*U*
NDR 97	*PVS, Nepal*		*1997*	*1998*	*ML*
Judi 141F	PPB	KIII/IR64	2002	2003	U
Judi 503	PPB	KIII/IR64	2002	2005	ML
Judi 547	PPB	KIII/IR64	2002	2005	ML
Judi 572	PPB	R32/KIII	2003	2004	ML

† Less popular, niche varieties, in italics

1 Also suitable for upland main-season conditions

2 NARC identified variety originally from Sri Lanka released as Hardinath 1 in 2004 in response to LI-BIRD PVS programme results.

Table 2. Increasing availability of varietal choice for the Terai. Farmer-accepted varieties for the main season, 1997 to 2005. Varieties underlined and in bold were recommended in a National Workshop in July 2004 along with Judi 566.

Variety†	Source (method, country)	Pedigree of PPB varieties	First year tested	First year with > 500kg seed	Situation
Pant Dhan 10	PVS, India[1]		1997	1997	U, MU, ML
PNR 381	PVS, India[1]		1997	1997	U, MU, ML
Swarna	PVS, India[1]		1997	1997	L
Rampur Masuli	PVS, Nepal[2]		1997	1998	MU, ML
BG1442	PVS, Nepal[3]		1998	1999	U, MU, ML
Sarwati	PVS, India[1]		1998	1999	U, MU
Ekhattar	*PVS, Nepal[4]*		*1998*	*1999*	*MU*
Radha 82	PVS, Nepal[5]		1998	1999	MU, ML
IAASR32	*PVS, Nepal[6]*		*2000*	*2001*	*ML*
IAASR16	*PVS, Nepal[6]*		*2001*	*2002*	*MU, ML*
Sugandha 1	PPB	IPB	2001	2002	U
Barkhe 1027	PPB	KIII/IR64	2001	2002	U, MU (drier west)
Barkhe 2001	PPB	IPB	2001	2003	MU, ML
Barkhe 3004	PPB	KIII/IR64	2001	2002	MU, ML, L
Barkhe 2014	PPB	KIII/IR64	2002	2003	MU, ML
Judi 572	PPB	R32/KIII	2002	2003	U (main and bhadaiya)
Judi 567	PPB	R32/KIII	2003	2004	Barind, Bangladesh
Judi 582	PPB	R32/KIII	2003	2004	Barind, Bangladesh
Barkhe 1006	PPB	IPB	2003	2005	U, MU
Sugandha 2002	PPB	IPB	2003	2004	MU
Barkhe 2024	PPB	KIII/IR64	2003	2005	MU, ML
Pipeline varieties					
Barkhe 3015	PPB	Masuli/MT4	2004	2005	ML, L
Barkhe 1019M	PPB	KIII/IR64	2004	2005	U, MU
Barkhe 2045	PPB	Masuli/MT4	2004	2005	MU, ML
Barkhe 3017[7]	PPB	Masuli/Laxmi	2004	2005	ML, L

† Less popular, niche varieties, in italics

1 Indian varieties introduced by LI-BIRD

2 NARC variety released in 1999

3 NARC-identified but non-released variety originally from Sri Lanka

4 NARC-identified but non-released variety from IRRI.

5 NARC-identified but non-released variety from India

6 These are from IAAS, not from NARC, the source of all other Nepalese varieties in PVS

7. Bred initially by IAAS and tested by LI-BIRD.

Annex 3. Assumptions Used

ASSUMPTIONS ON VARIETAL SPREAD IN NEPAL

Example of farmer-to-farmer spread in *Chaite* rice

In the PVS, farmers test varieties on their own fields and preferred varieties start to spread rapidly from farmer to farmer from farm-saved seed. Activities began in Chitwan in the *Chaite* season of 1997 and DTZ Pieda Consulting, Edinburgh, conducted an impact assessment on *Chaite* rice. They found that by the 1999 *Chaite* season there were 35 ha of rice under project-introduced varieties. By 2002 this impact had greatly increased with 1200 ha under one project-introduced *Chaite* rice variety (BG 1442), and 50 ha under other project varieties[†]. This is more than a trebling of area each year in each of the three seasons following 1999.

Studies in Chitwan showed the rapid spread of rice varieties by farmer-to-farmer spread. By this mechanism, rice variety Kalinga III, introduced from India, increased nearly 9 fold in area from the 1997 main season to the 1998 *Chaite* season (see Annex 2). Variety NDR 97, a non-released national programme variety, increased over 30 fold from *Chaite* 1997 to *Chaite* 1998 (see Annex 2). Hence, particular varieties in particular cultivations can spread extremely rapidly.

More recent studies quantified the spread in Chitwan from 2001 to 2002. In these extensive surveys varieties spread at a rate of 1.5 fold to over 20 fold for varieties liked by farmers that are in an early stage of adoption. PPB varieties spread at a rate of over 5 fold from 2001 to 2002.

Examples of farmer-to-farmer spread in main-season rice

In 2001, DADO, Kailali, distributed a total of 300 kg of seed of eight project bred or identified, main-season varieties. By 2002, a survey by DADO showed that a total of about 1.4 t of seed of these eight varieties was seeded in nurseries for the 2002 main season, which is sufficient for transplanting into 28 ha. This represents an increase of over four fold in a single season.

This is a higher rate of spread of main season varieties than was found in the initial years, 1997 and 1998, in Chitwan when only two main-season varieties (Pant Dhan 10 and Swarna) had been identified. Both of these varieties are adapted to specific niches. Pant Dhan 10 is an early variety adopted by vegetable growers - the early harvest allows earlier sowing of vegetables - whereas Swarna is adapted to long-standing water conditions.

[†] Provisional survey data by LI-BIRD and DADO Chitwan

Assumptions made on spread

The two examples above, for BG 1442 in *Chaite* rice in Chitwan and main-season rice in Kailali district, gave an observed rate of spread of over a trebling each year. On the basis of all these examples, we have used the somewhat lower estimates for our scenarios that the project rice varieties increase at rates of a maximum of a trebling in any one year. Whatever rate of increase is assumed, it is reduced to follow an s-shaped adoption curve with a maximum adoption of about 50% of the rice area (note that BG 1442 already occupies 35% of the area after 5 years and is expected to increase again next year).

The assumptions used are generally conservative
We argue that this estimate on the rate of spread is conservative because of several factors:

1. ***Formal seed supply is underestimated.*** The benefits are very sensitive to additional seed supply in early years i.e. a modest additional amount of project-supplied seed early in the adoption process has a large impact on increasing benefits. LI-BIRD, DADOs, and other partners in scaling up the varieties, are expected to supply considerably more seed than the assumed maximum of 7 ha of seed in the higher scenario in each district in the first three years of adoption. The partners in the scaling up (Supplement 6) have increased in number and the Department of Agriculture is using its own resources to supply seed of the varieties that farmers are demanding. (As explained above, this is not considered to be an additional cost when NPV is calculated because DADOs, prior to having project-identified or project-bred varieties, still used resources on front-line demonstrations and minikits of varieties).

2. ***Spillover to new districts is underestimated***: The spread to new districts from the large areas under project varieties has not been included when estimating benefits, although the increased area under new varieties is accounted for in the estimated farmer-to-farmer spread within districts. An estimated total of about 2000 ha of main-season rice under project varieties in 2002[†] represents a very large seed source, in the hands of many farmers, that was not present in previous years.

   In *Chaite* rice there is now 1200 ha in Chitwan of BG 1442. Because of the low average landholdings, about 2000 households are now growing this variety. It is improbable that farmers in these households have failed to give seed of the variety to relatives in other districts. We have found that a major element of the spread of seed from farmer to farmer is among relatives and networks of relatives commonly spread across districts.

[†] In 2002, there were at least 600 ha (LI-BIRD estimate) of project, main-season varieties in Chitwan (DADO estimate is 750 ha or 2.5% of the rice area). There were estimated to be 300 ha of project varieties in Nawalparasi in 2001. If the spread in Nawalparasi is similar to that of Chitwan, then there are 600-700 ha of project varieties in 2002 in Nawalparasi. From field data from collaborating DADOs and NGOs, it is estimated that there is about 500 ha in other districts where the project began interventions in 2001. This gives a total of at least 2000 ha.

Because the quantities of seed given in farmer-to-farmer spread are modest, the quantities of seed in this spillover will also be modest. However, additional small quantities of seed in early years have a large impact on adoption in later years.

3. ***There is a greater varietal choice that matches more of the rice ecosystems:*** The varietal choice that can now be offered has increased dramatically and will continue to increase greatly at least until 2004 (Fig. 6). The varietal choice (Annex 2) is increasingly meeting the needs of farmers. Varieties are now available that fit well to the 60% of the Terai that is rainfed or under limited irrigation.

4. ***Two generations a year of main-season rice can now be grown.*** The *Chaite* season can be used to advance very early duration main-season varieties and the main season can be used to advance *Chaite* rice varieties. However, before 2001 it was not possible to grow two generations a year of longer-duration main season varieties. The PTD projects have identified an area in Nawalparasi where longer-duration main-season rice can be multiplied in the off-season. This was done for the first time in the 2001-2002 winter season (Fig. 3.1). This ability to multiply new main- season varieties in the off-season (two crops a year instead of one) greatly aids seed multiplication and hence dissemination and impact.

6. ***Not all districts are accounted for.*** We have restricted the benefit analysis to the 21 districts in which there has been project-initiated scaling up and to two (Makwanpur and Rupandehi) which border on the projects' districts of Nawalparasi and Chitwan. However, there are several districts, where farmer-to-farmer seed spread is already taking place and in some of the 14 hill districts adjoining the Terai that have a total of 134,000 ha of main-season rice GOs or NGOs have already taken up extension activities on these varieties.

7. ***The start dates for spread are conservative.*** Although some seed will have spread earlier from farmer-to-farmer or by informal intervention by staff from GOs and NGOs, we have assumed the spread only began from project interventions.

Figure 3.1. **Barkhe 2001 in winter season multiplication, May 2002**

Possible overestimates

1. Project-identified varieties may prove unpopular. This is the most sensitive of the possible overestimates, because all of the scenarios assume that the project varieties are preferred and spread from farmer to farmer. However, there is very strong evidence for the high adoption of varieties BG1442 and Swarna. The popularity of other varieties, such as Pant 10, Barkhe 1027, Barkhe 2001, Barkhe 3004 and Sugandha 1, is evidenced by the high rate of their seed distribution by farmers and the positive responses from in-depth interviews. Moreover, evidence for acceptability has been generated by participatory methods (project varieties are the top-ranked entries in mother trials) and all project varieties have undergone organoleptic testing and have good or excellent post-harvest traits.

2. For varieties introduced from India by the project there is the possibility that some of these varieties would have been adopted anyway entirely by farmer-to-farmer spread, as has been the case for many Indian varieties in the past. However, farmer-to-farmer spread of Indian varieties is haphazard (it may not occur at all if no farmer introduces the variety) and (as can be seen from the assumptions of spread in our benefit analysis) without the benefit of an initial, project-supported seed supply it will be extremely slow in the initial stages. Since the analysis has only been taken to 2012, the 'no-project' scenario could be expected to have little, or no, benefit from the Indian varieties that have been introduced by the project.

3. For the varieties produced by PPB it is assumed that, in the absence of the project, NARC would not increase the rate of release of varieties for the Terai.

4. For the PPB varieties, it is assumed that there will be some support from NGOs and DADO to maintain a supply of source seed. Costs have been allocated throughout the entire period to allow for this. Moreover, some of the varieties may be officially supported by NARC if they perform well in official NARC trials.

5. It is possible that farmers or NARC could identify new varieties superior to those identified by the project and would thus prevent, or slow, the spread of project-identified or project-created varieties. However, as the adoption ceilings considered are conservative (a maximum of 40 %) then there is plenty of scope for the adoption of non-project varieties.

6. Project varieties may break down to disease. However, all have shown excellent field resistance and resistance in disease nurseries when they have been tested in NARC trials. It is considered more likely that the continuing breakdown of resistance in existing popular varieties, such as CH 45, Masuli and Sabitri that are increasingly disease susceptible, will accelerate the adoption of project varieties, rather than susceptibility of project varieties limiting their spread.

ASSUMPTIONS ON BENEFIT PER HECTARE TO FARMERS

Benefits of new varieties were previously calculated (DTZ Pieda, 1998) on the basis of

- an increased harvest due to the new variety of 500 kg ha^{-1} after any additional costs
- a market price of Rs 9 kg^{-1}
- an exchange rate of Rs 107 per £

This gives benefits of Rs 4500 =£42 ha^{-1}.

We have adjusted these prices to 2001 data of Rs 8 to 9 kg^{-1} and an exchange rate of Rs 120 per £. This gives a benefit that varies from £33.33 to £37.5 ha^{-1}. However, the new varieties, on average, give up to 1 t ha^{-1} more and their grain quality is often superior, sometimes markedly so, to existing varieties so, for most varieties, this is an underestimate of benefits. We have hence used three estimates of benefits of £20, £33 and £46 per hectare.

We have used a discount rate of 10% to estimate net present value.

Short duration rice varieties for the High Barind Tract of Bangladesh: the Initial impact of varieties from client oriented breeding and selection in Nepal

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EXECUTIVE SUMMARY

This paper describes the huge potential impact that products of client-oriented breeding (COB) in Nepal can have on improving rice production in Bangladesh. Studies in Bangladesh found that short duration rice (SDR) varieties bred by COB in Nepal out-performed all other varieties.

Participatory research on transplanted main season (*t. aman*) rice was conducted in 2003 in the HBT of Bangladesh to identify farmer-preferred rice varieties that gave high returns, fitted with local cropping patterns and that could enhance productivity and crop diversity. In 2003, over 190 farmers participated in the trials and in seed production.

Eleven rice varieties were introduced from Nepal. The first five varieties had previously been identified using participatory method by the NGO Local Initiatives for Biodiversity Research and Development (LI-BIRD) and CAZS, University of Wales, Bangor. The remaining six varieties were bred using client-oriented breeding by a LI-BIRD–CAZS-NARC collaboration.

Participatory varietal selection (PVS) was used to test the varieties in mother and baby trials. In these trials farmers tested the varieties in their fields using farmers' levels of inputs. The rice varieties were evaluated using focus group discussion, preference ranking, household level questionnaires and in depth interviews.

Grain and straw yields of the SDRs from Nepal were similar to, or exceeded, the check varieties that were the farmers' customary varieties and the recent, recommended varieties from BRRI. The highest yielding, Judi 567, out-yielded the most productive check variety, Swarna, by 34%. All the SDRs from Nepal were significantly earlier than the check varieties and as much as three to four weeks earlier than the most widely grown variety Swarna.

Most of the new varieties were preferred to the check varieties in all locations because of their early maturity, high yield potential, good grain quality, market price, input responsiveness, lodging-resistance and ease of threshing.

The majority of collaborating farmers intended to grow the test entries in the either or both of the main *(aman)* or *boro* (winter) seasons. The demand for the seeds of new varieties is increasing in all the project villages. Farmer-to-farmer seed spread was found.

Spillover effect in the boro season
Farmers decided to grow the SDRs during the *boro* season because they had appreciated their performance in the previous season. They said that the SDRs:

- Overall out-yielded all the existing *boro* rice varieties by over 30%.
- Were considered '*khara sahinsh'*, meaning drought-tolerant, by the participating farmers. There was a saving of 2-3 irrigations with SDRs as they matured earlier and were more drought-tolerant.
- Required less fertilizer and were more responsive to the applied inputs.
- Did not lodge.

- Have better grain quality, required less cooking time and taste better.
- Fetched a similar price in the market to that of the best selling *boro* varieties, such as Minikit.

Monitoring showed that 410 kg of seed of various SDRs was distributed to 67 farmers by 11 farmers in the villages (a six-fold increase in farmer number, and averaging over 6 kg of seed per farmer).

The project has greatly increased farmer access to a choice of new, short duration, farmer-preferred rice varieties in the rural HBT of Bangladesh using a simple, rapid, and cost-effective approach to identifying and disseminating new rice varieties.

INTRODUCTION

Rice systems in Bangladesh

Rice, the staple food crop of Bangladesh, is grown on over 10 million ha and it is historically associated with culture, rites and rituals of Bangladeshi people. The millennium development goal of the elimination of extreme poverty and hunger can only be met in Bangladesh by increasing rice productivity as it accounts for 95% of food grain production. Over 90% people depend on rice for their daily diets and it engages over 65% of the total agricultural labour force. Among the rice growing countries of the world, Bangladesh ranks third in area and fourth in production (Huke and Huke, 1990).

The rice-growing ecosystems in Bangladesh are diverse and modern varieties cover almost 56% of the total rice area (Das *et al*., 2001). The various types of rice grown in Bangladesh are summarised in Table 1. BRRI-developed rice varieties are suitable for favourable rice growing ecosystems but there has been lower adoption of these varieties in less favourable conditions.

Table 1. Types of rice culture and their relative importance in Bangladesh.

Rice type	Normal growing period	Area (million ha)	Area (%)
Broadcast *aman* (includes deep water rice)	Jun-Dec	0.8	7
Transplanted *aman*	Jun-Dec	4.9	46
Boro (winter, irrigated)	Dec-Apr	3.7	34
Aus (mainly broadcast)	Apr-Aug	1.4	13
Total		10.7	

Source: Bhuiyan (2004); data are for 2000.

More than 3 million ha of rice is affected by drought during both the dry and wet seasons (Das *et al*., 2001). A considerable area of *boro* rice in the High Barind Tract (HBT) is grown under partially irrigated conditions, especially in recent seasons, due to declining water tables and decreasing supply of electricity for deep tube wells. As a result, farmers in all the study villages of the study strongly desired to have drought-tolerant *boro* rice varieties.

The human development scenario

Nearly 30% of the population live below $1 a day and nearly 80% are below $2 a day. About 35% of people are under nourished and nearly 48% of children below 5 years of age are under weight and 45% show stunted growth. While the per capita income was one of the lowest in the world, the density of population was among the highest (UNDP, 2003).

The population of Bangladesh is increasing at 1.8% per annum and annual food deficit is 1.8 million tons (Uddin, 2001). The demand for rice is rapidly increasing with the increase in population and this demand is the highest in Bangladesh among the least developed countries (Virmani et al., 1997). Contrary to this, the increase in

the productivity of rice is hardly keeping pace with the population growth rate. In the last decade rice yields have failed to increase (Islam et al., 2001).

Background to the study

The HBT of Bangladesh is situated in the north-west of Bangladesh with an area of 1600 km ^{2} (160,000 ha). The predominant soil type is silty loam to silty clay loam with very low organic matter content, high bulk density, and low pH. The rainfall in the area is erratic and low (average 1300 mm per annum) and is concentrated between June and September. The only traditional crop grown during the rainy season is *t. aman* rice, provided that the rain arrives in time. Lands remain fallow in the winter (*rabi* season) after the harvest of *t. aman* rice. In recent years, farmers have started to grow *rabi* season crops on residual soil moisture (e.g. chickpea, linseed, barley, mustard) with chickpea, in particular, being successful and promoted by PROVA (Peoples Resource Oriented Voluntary Association) in collaboration with CAZS.

In order to ensure the timely sowing of *rabi* crops in November in the HBT there is a need to identify *t. aman* rice genotypes of considerably shorter duration than the commonly cultivated Swarna, but with comparable yields and grain quality. Some BRRI-released rice varieties with shorter durations than Swarna are available, namely BRRIdhan 32, 33 and 39, but these varieties have various shortcomings and have not been readily adopted by farmers in the HBT.

In the 2002 rainy season, seven short duration rice varieties were supplied to PROVA by LI-BIRD through the CAZS research coordinator based in Kathmandu. LI-BIRD and CAZS have been jointly working in Nepal to develop rice varieties using client-oriented breeding (COB) approaches (also called participatory plant breeding, PPB) for a range of agroecological conditions.

Participatory varietal selection (PVS) procedures are increasingly being used to involve farmers in the varietal selection process, and thereby increase the likelihood of farmer adoption of superior varieties (Witcombe *et al.*, 1996; IPGRI, 1996; Weltzein *et al*, 2000; Witcombe *et al*., 2002). This study used the PVS procedures recommended by Witcombe *et al*. (2002).

METHODS

'Mother' and 'Baby' trials were used in this study. Mother trials are analogous to on-station research trials in that they generate statistical data on yield per unit area. Baby trials are designed to give data on farmers' perceptions and acceptance of varieties. The Mother trials comprised a multi-entry, single replicate trial, replicated across several farmers whilst the Baby trials involve paired comparison of new varieties with the farmer's existing variety under the farmer's own management conditions.

Mother trials

Two sets of Mother trials were conducted during the 2003 season. Mother trial 'A' involved rice varieties previously evaluated during the 2002 season, while Mother trial 'B' had a new set of entries that were bred using COB approaches (Tables 2 and

Table 3). Mother trials 'A' and 'B' were conducted across one *Upozilla* (sub-district), each consisting of three districts and with three participants in each[1].

Baby trials

Five varieties were included in the Baby trials across three districts (Table 4) involving 155 farmers (However, data were collected from 78 farmers). Grain yield data were available from 42 farmers; 14 for Pant Dhan 10, 10 farmers for Judi 582, 7 farmers each for Sugandha 1 and Ekhattar and only four farmers for PNR 381. Post-harvest evaluation data were available for 78 farmers (Table 4).

Table 2. Summary of mother trials and seed production using short duration rice varieties (SDRs) from Nepal, 2003.

Activity	SDR variety	Number of participating farmers (replication) by sub district		
		Godagai	Porsha	Nachole
Mother Trial 'A'	PNR 381, Pant Dhan 10, Ekhattar, Sugandha 1, Judi582, BG 1442 Swarna, BRRIdhan 32, BRRIdhan 39	3	3	3
Mother Trial 'B'	Barkhe 2001, Judi 565, Judi 566, Judi 567, Swarna, BRRIdhan 32, BRRIdhan 39	3	2	3
Seed production	Pant Dhan 10, Sugandha 1, Judi 582, BG 1442, BRRIdhan 32, Judi 565, Sarwati, BRRIdhan 39, Barkhe 2001, Judi 566, Judi 567	20	-	-

Evaluation

The Mother and Baby trials were evaluated by measuring quantitative traits, farm walks, focus group discussion (FGD) and farmers' preference ranking. Household-level questionnaires (HLQ) were done only in the case of Baby trials.

Statistical analysis

Analysis of variance was done for grain and straw yield data for the Mother trials using Genstat (version Genwin32). A paired t test was done for Baby trial data for four varieties; PNR 381 was excluded from this analysis there were too few replicates. Farmers' perceptions from both Mother and Baby trials were analysed using SPSS 11.

[1]One of the Mother 'B' trials could not be planted at Naogaon as the seedlings were stolen and so there were only 8 participants for this trial set.

Table 3. Details of the short duration rice varieties which were identified by PVS or bred by COB in Nepal and used in participatory trials and seed production, 2003.

Name of rice variety	Year of introduction by PROVA	Origin
Barkhe 2001	2003	COB, Nepal
BG 1442	2002	PVS, Nepal
Ekahattar	2002	IRRI
Judi 565	2003	COB, Nepal
Judi 566	2003	COB, Nepal
Judi 567	2003	COB, Nepal
Judi 582	2002	COB, Nepal
Pant Dhan 10	2002	PVS, Nepal
PNR-381	2002	PVS, Nepal
Sarwati	2002	PVS, Nepal
Sugandha 1	2002	COB, Nepal

Table 4. Distribution of baby trials using short duration rice varieties (SDRs) from Nepal in various villages in High Barind Tract, Bangladesh, 2003

District, *Upozilla* (Sub-district)	Village	Number† of baby trials by varieties					
		Pant Dhan 10	Sugandha 1	PNR 381	Judi 582	Ekhattar	Total
Rajshahi, Godagari	Chaubisnagar	5	1	2	2	2	12
	Kakanhat	-	2	1	1	1	5
	Digram	1	1	1	1	-	4
	Amoti	-	1	1	2	-	4
	Hatatpara						
	Kazipara	1	2	-	1	-	4
	Amtoli	-	-	-	-	1	1
Naogaon, Porsha	Shoharanda	4	2	1	3	-	10
	Uporsisha	1	1	1	1	-	4
	Jofarpur	1	1	1	1		4
	Ghatnagar	3	-	-	2	1	6
Nawabganj, Nachole	Baypur	4	4	-	2	-	10
	Borandha	1	1	-	2	-	4
	Pukriyapara	1	1	1	-	2	5
	Nizampur	-	2	-	2	1	5
	Total	22	19	9	20	8	78

† - indicates no baby trial was given

RESULTS AND DISCUSSION

Results from 2002 season

Promising results were obtained for five of the new varieties, showing yields greater than or equal to the check cultivars BRRIdhan 32 and Swarna and having durations 3-4 weeks shorter than the checks. Judi 582, which is a product of COB, had the highest grain yield and was three weeks earlier to mature than Swarna, the latest variety in the trial (Table 5).

Table 5. Varietal performance (in two farmers fields) of short duration rice varieties from Nepal under rainfed conditions in Rajshahi, Bangladesh and differences in maturity between varieties grown in Bangladesh and Nepal, 2002 (Rajshahi data are based on two observations).

	Days to maturity in:		Yield (t ha $^{-1}$)	
Rice variety	Rajshahi	Chitwan Nepal	Grain	Straw
Judi 582	118	120-125	4.0	5.2
Ekahattar	109	120-125	3.9	4.3
Ekahattar	109	120-125	3.9	4.3
PNR-381	119	110-115	3.8	5.5
Sugandha 1	107	120-125	3.8	5.1
Pant Dhan 10	104	115-119	3.8	3.7
Swarna	139	160-165	3.3	4.5
BG 1442	102	110-115	3.3	3.1
BRRIdhan 32	136	NA	3.7	5.7
Sarwati	113	120-125	3.1	5.5
Mean	116	122-127	3.7	4.7

NA = not applicable

Results from 2003

Mother trials

Mother trial 'A'
The grain and straw yields of the short duration rice (SDR) varieties were comparable to, or better than, those of the three check varieties, Swarna, BRRIdhan 32 and BRRIdhan 39. Judi 582 produced the highest grain yield, followed by Pant Dhan 10 and BRRIdhan 39 (Table 6). Similarly, Judi 582 produced the greatest straw yield (Table 6).

Differences in crop maturity were highly significant (P<0.001). The SDRs from Nepal and the 'check' varieties fell into four distinct maturity classes: BG 1442, Pant Dhan 10 and Ekhattar were the earliest group; PNR 381, Sugandha 1 and Judi 582 the medium maturity group; whilst the 'check' varieties BRRIdhan 32, BRRIdhan 39 and Swarna were the latest (Table 6).

Table 6. **Grain and straw yield and crop duration of the short duration rice varieties from Nepal and the three 'check' varieties (i.e. Swarna, BRRIdhan 39 and BRRIdhan 32) grown under farmers management across the High Barind Tract of Bangladesh, 2003 (Mother trial 'A'). Means of three districts (Rajshahi, Naogaon and Nawabganji).**

Rice variety	Grain yield (t ha $^{-1}$)	Straw yield (t ha $^{-1}$)	Crop duration (days)
Judi 582	2.8	3.9	111
Pant Dhan 10	2.4	3.4	100
BRRIdhan 39	2.2	3.7	117
PNR 381	2.1	3.1	112
Swarna	2.0	3.7	128
Ekhattar	2.0	3.6	101
Sugandha 1	1.9	3.3	109
BG 1442	1.9	2.9	99
BRRIdhan 32	1.8	3.3	116
Mean	2.1ns	3.4ns	110***
SE	±0.34	±0.44	±1.9

In addition to measured yield, several focus group discussions (FGDs) were organized to obtain the preference rankings of test entries by the farmers at different locations (Table 7). Judi 582 was consistently and significantly ranked the best by farmers in all the three regions, followed by Pant Dhan 10. The check varieties Swarna, BRRIdhan 32 and 39 were significantly the least preferred even though Swarna and BRRIdhan 32 were not the lowest yielding. The reasons for preference of Swarna over BRRIdhan 39 are several; BRRIdhan 39 is susceptible to gall midge, has coarser grains so it fetches a lower price in the market and it also takes more time to cook and does not taste as good.

Table 7. Summary of overall mean preference ranks[§] for short duration rice varieties from Nepal across three districts of High Barind Tract of Bangladesh, 2003 (Mother trial 'A')

	Rajshahi				Naogaon				Nawabganj				
Variety	1 n = 7	2 n = 7	3 n = 10	Site mean rank	1 n = 8	2 n =5	3 n = 9	Site mean rank	1 n =8	2 n = 5	3 n = 9	Site mean rank	Overall mean preference rank
Judi 582	3	1	2	2	1	1	1	1	1	2	1	1	**1**
Pant Dhan 10	1	4	2	2	2	2	2	2	2	0	0	1	**2**
PNR 381	5	2	1	3	4	3	5	4	6	1	2	3	**3**
Sugandha 1	2	5	2	3	6	5	3	5	5	4	3	4	**4**
BG 1442	3	6	5	5	5	8	5	6	4	0	0	1	**4**
Ekhattar	6	2	6	5	8	7	6	7	3	7	7	6	**6**
Swarna	7	7	7	7	6	4	4	5	7	3	5	5	**6**
BRRIdhan 32	8	8	8	8	9	0	8	6	8	5	6	6	**8**
BRRIdhan 39	9	9	7	8	7	6	7	7	9	6	4	6	**8**
Mean													**4.6*** **
S.e.d.													**0.7**

[§] 1 = best, 9 = worst; n = number of farmers participated in the ranking

Mother trial 'B'

There was significant difference among test varieties for grain yield. Judi 567 was the highest yielding variety followed by Barkhe 2001 and Judi 566 (Table 8). Judi 567 yielded 34% more than Swarna, the highest yielding among the check varieties. Judi 567 also had the highest straw yield, followed by both Swarna and BRRIdhan 39 (Table 8).

There was no effect of location on the grain yield indicating that the rice varieties would perform similarly across a range of environments close to those used in the trials.

There were significant differences in crop duration ($P<0.001$) with the new SDRs from Nepal as much as 3 to 4 weeks earlier than the check variety Swarna (Table 8).

Table 8. **Grain and straw yield and crop duration of short duration rice varieties from Nepal and the three 'check' varieties (i.e. Swarna, BRRIdhan 39 and BRRIdhan 32) grown under farmers management across the High Barind Tract of Bangladesh, 2003 (Mother trial 'B'). Mean of three districts (Rajshahi, Naogaon and Nawabganj).**

Rice variety	Grain yield (t ha $^{-1}$)	Straw yield (t ha $^{-1}$)	Crop duration (days)
Judi 567	3.5	4.7	102
Judi 566	2.7	3.7	99
Judi 565	2.6	3.6	99
Swarna	2.5	4.1	128
Barkhe 2001	2.5	3.9	115
BRRIdhan 39	2.5	4.1	116
BRRIdhan 32	2.1	3.7	115
Mean	2.7**	4.0**	111***
S.e.d.	0.32	0.3	2.2

Several FGDs were organized for the Mother 'B' trials. Preference ranking for the short duration rice (SDR) varieties relative to the check varieties revealed that Judi 567 was consistently and significantly the most preferred variety followed by Barkhe 2001 (Table 9). The farmers overall preference ranks for SDR varieties agreed perfectly with the grain yield of the varieties.

Table 9. Summary of overall mean preference ranks[§] for short duration rice varieties from Nepal across three districts of the High Barind Tract of Bangladesh, 2003 (Mother trial 'B')

	Rajshahi				Naogaon			Nawabganj				
Variety	**1 n = 7**	**2 n = 7**	**3 n = 10**	**Site mean rank**	**1 n = 8**	**2 n =5**	**Site mean rank**	**1 n =8**	**2 n = 5**	**3 n = 9**	**Site mean rank**	**Overall mean preference rank**
Judi 567	1	1	1	1	1	1	1	1	1	1	1	**1**
Barkhe 2001	2	1	2	2	2	2	2	2	2	3	2	**2**
Judi 566	4	4	3	4	3	3	3	3	6	2	4	**3**
Judi 565	3	3	4	3	6	4	5	4	4	5	4	**4**
Swarna	5	6	5	5	5	6	6	4	3	3	3	**5**
BRRIdhan 39	7	7	6	7	4	4	4	7	4	6	6	**5**
BRRIdhan 32	6	5	6	6	7	6	7	6	6	7	6	**7**
Mean												**3.9*** **
S.e.d.												**0.5**

[§] 1 = best, 7 = worst; n = number of farmers participated in the ranking

Baby trials

In the Baby trials the test varieties did not significantly differ from the check varieties except for Pant Dhan 10 (Fig. 1)[2]. Pant Dhan 10 gave almost a 14% yield advantage over all the check varieties. However, the test varieties were significantly earlier maturing than the check varieties (Fig. 2). Early maturity is an important trait across the HBT of Bangladesh as late maturing varieties such as Swarna or the BRRI lines are susceptible to yield losses caused by end-of-season drought. Another very important implication of early maturity is that the succeeding winter crops planted after a late variety (e.g. Swarna) are subjected to greater of drought stress and hence poor stand establishment at the time of late planting.

Post harvest evaluation of the SDR varieties from Nepal revealed that 100% of farmers considered them to be earlier maturing than the check varieties (Table 10). Farmers were also overwhelmingly of the opinion that grain quality of all the SDRs was superior. In the case of grain yield, however, the response was more variable with the majority of farmers considering only Judi 582 and Pant Dhan 10 to be higher yielding than the check varieties (Table 10).

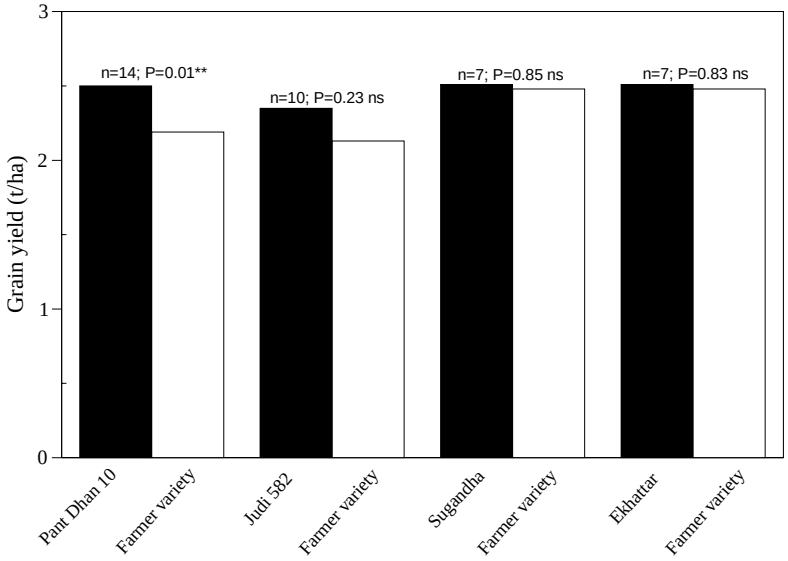


Figure 1. **Comparison of grain yield of short duration rice varieties from Nepal and farmers' varieties under farmers' management in the High Barind Tract of Bangladesh, 2003 (Baby trial), where *n* is the number of participating farmers and P the level of significance for the comparison.**

[2] This is not unexpected as the number of trials for the non-significant cases is never above 10.

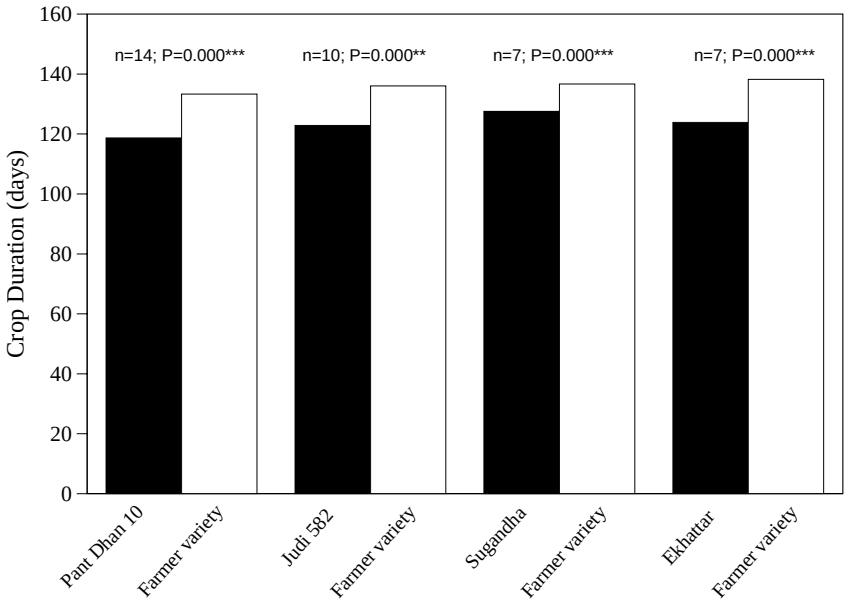


Figure 2. **Comparison of crop duration of short duration rice varieties from Nepal and farmers' varieties under farmers' management in the High Barind Tract of Bangladesh, 2003 Baby trials, where *n* is the number of participating farmers and P the level of significance for the comparison.**

For market price, 100% farmers said that PNR 381 would fetch a higher price than existing check varieties, and over 70 said this for the rest of the varieties except Ekhattar. The most interesting and important message from the household level evaluation is that the majority of the farmers were in favour of growing the SDRs next year. The most preferred were Judi 582, Pant Dhan 10 and PNR 381 (Table 10).

These exercises really show the power of participatory approaches. Farmers' decisions to continue growing SDRs next year are not only based on the level of grain yield alone. Several other criteria were also important in influencing farmers' adoption decisions.

Table 10. Farmers' perceptions of short duration rice varieties from Nepal across three districts of the High Barind Tract of Bangladesh relative to check varieties.

	Number of Farmers				
Judi 582	**SDR from Nepal preferred**	**SDR and check variety equally preferred**	**Check variety preferred**	**Percentage of farmers preferring the SDR from Nepal**	**Probability[1]**
Earliness	13	0	0	100	<0.001
Grain yield	10	2	1	77	Ns
Grain quality	11	2	0	85	<0.05
Market price	10	2	0	83	Ns
Growing next year	12	0	1	92	<0.01
Pant Dhan 10					
Earliness	21	0	0	100	<0.001
Grain yield	15	2	4	71	<0.05
Grain quality	20	1	0	95	<0.001
Market price	15	6	0	71	<0.001
Growing next year	20	0	1	95	<0.001
Suhgandha 1					
Earliness	24	0	0	100	<0.001
Grain yield	9	4	10	39	Ns
Grain quality	21	2	1	88	<0.001
Market price	20	4	0	83	<0.001
Growing next year	17	0	7	71	Ns
PNR 381					
Earliness	9	0	0	100	<0.01
Grain yield	4	2	3	44	Ns
Grain quality	8	1	0	89	<0.05
Market price	9	0	0	100	<0.01
Growing next year	9	0	0	100	<0.01
Ekhattar					
Earliness	8	0	0	100	<0.05
Grain yield	1	1	6	13	Ns
Grain quality	6	2	0	75	<0.05
Market price	0	8	0	0	<0.05
Growing next year	6	0	2	75	Ns

[1]from χ^2 test

Quality and disease attributes of rice varieties included in Mother and Baby trials

A few important quality traits and disease scores of rice varieties developed through COB have been summarised (Table 11). In COB it is essential that all entries are tested in a disease screening nursery.

Table 11. Summary of the quality and other traits of COB lines.

Rice variety	Milling %	Eating quality	Disease score		Ease of threshing
			Blast	BLB†	
Judi 565	65	Selected by the test panel	0	5	Easy
Judi 566	69	Selected by the test panel	1	5	Easy
Judi 567	69	Selected by the test panel	3	5	Easy
Judi 582	68	Moderately preferred	NA	NA	Hard
Sugandha 1	68	Selected by the test panel	1	7	Easy

† BLB = Bacterial leaf blight

Source: LI-BIRD unpublished data

Community based seed production programme

Considering the popularity of the rice varieties in the Mother and Baby trials, PROVA initiated community based seed production in different parts of the project villages. In total over 2.3 t of rice seed (see Annex 2) was procured from the farmers, and a quantity of the seed of each variety was left behind with the participating farmers for their own use and also to encourage farmer-to-farmer seed dissemination. The collected seed was used in composing Mother and Baby trials, seed multiplication and also used as Informal Research and Development (IRD) kits in order to disseminate the farmer-preferred varieties much more widely. Some of the seed of these varieties were also shared with the network of the Wheat Research Centre (WRC) and BRRI Regional Station, Rajshahi.

Spillover effect on boro *rice in 2003 – 2004*

The project did not plan any activities for the *boro* rice season (i.e. winter season under irrigation). Later the project staff discovered that farmers in most of the project villages assessed most of the varieties that were in Mother and Baby trials during the *t. aman* season for their suitability as *boro* rice. Farmers have been growing a number of the varieties promoted through the informal system e.g. Minikit, Pariza, Noinmony and a few cases of BRRIdhan 28, which is an officially recommended *boro* rice variety. A crop cut survey in the *boro* season revealed that new rice lines introduced as *t. aman* varieties performed much better than BRRIdhan 28 (Fig. 3).

The overall yield advantage for the new varieties from crop cut data over all the existing *boro* varieties was 20% while the yield advantage of all the new varieties over BRRIdhan 28 was 31%. These data very much agree with the information from the in-depth interviews with selected farmers and strengthens our previous findings that farmers' perceptions are as reliable as quantitative data.

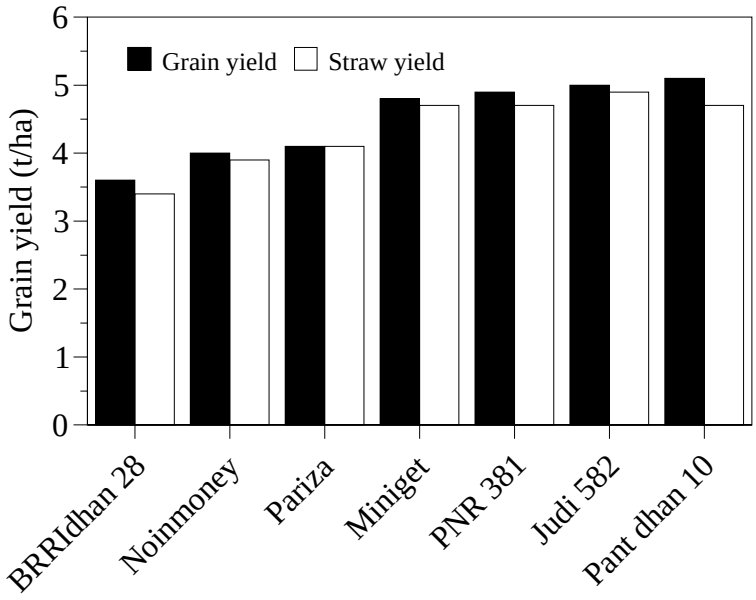


Figure 3. **Comparative performance (assessed by crop cuts) of short duration main season rice varieties from Nepal grown as *boro* rice under farmers' management in High Barind Tract of Bangladesh, 2004.**

Findings from in depth interviews with selected boro rice farmers

A short visit was organized in a few villages of the HBT of Bangladesh in May 2004 to monitor farmer uptake of the SDR varieties from Nepal as *boro* rice. Although these introduced varieties were mainly targeting *t. aman*, some farmers grew a few of these rice varieties in the *boro* season as well. The source of seed for these farmers was their own retained seed or from the seed obtained from farmer-to-farmer seed spread. The Judi rice lines were developed for the *Chaite* season rice planted during the month of February-March and harvested in June-July. In Nepal so they have some seedling-stage cold tolerance as well as drought tolerance.

The team visited a few households in various villages in Rajshahi district. Although the *boro* rice crop was already harvested the farmers were busy with threshing and other post-harvest operations. The main findings from the visit are summarised in Table 12 and individual in depth case studies are described separately below.

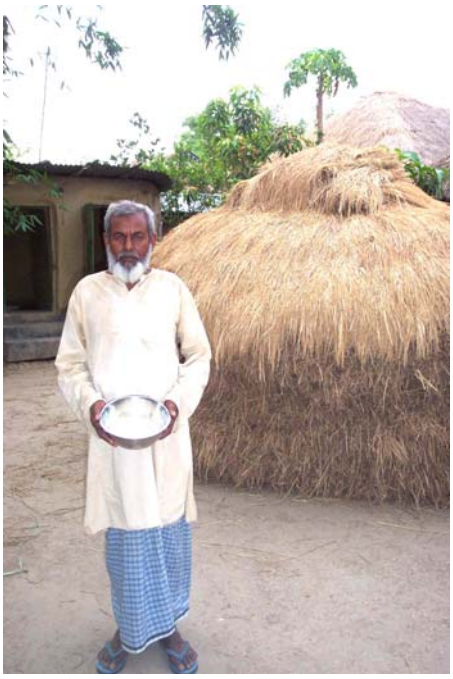
Table 12. Summary of farmers' uptake of short duration main season rice varieties from Nepal for *boro* planting in the High Barind Tract of Bangladesh, 2004

Farmer	District	Village	Variety Grown		Area SDR	Yield (t/ha)		Seed sold:		Willingness to grow	Remarks
			Local	SDR	m^2	Farmer's variety	SDR	kg	no of farmers	*t. aman*	
1. Nazurul Islam	Rajshahi	Chaubisnagar	BRRIdhan 28	Pant Dhan 10	998	3.6	4.1	100	20	✓	Seed sold also included that of Judi 582 & BG1442, intends to grow during *boro* also
2. Rojab Ali (A)	Rajshahi	Chaubisnagar	Parija, Nain Muni	Pant Dhan 10	1330	3.6	4.9	-	-	✓	He will find out more in *t. aman* & then decide whether to go for *boro*
3. Rossal	Rajshahi	Godagari		BG 1442	96	-	7.8			✓	Intends to grow in *aus* also
4. Rojab Ali (B)	Rajshahi	Chaubisnagar	BRRIdhan 28	Judi 582	333	4.5	5.6	100	20	✓	Seeds of Pant Dhan 10 sold but not Judi 582
5. Soyjuddin	Rajshahi	Godagari	Nain Muni	Pant Dhan 10	133	4.2	5.1	90	8	✓	
6. Rabi Tudu & Srimati Tudu	Rajshahi	Chaubisnagar	Parija, BRRIdhan 28	Pant Dhan 10	998	3.3	4.9	10	1	✓	
7. Lutfar Rahman		Nabogram	BRRIdhan 28	Judi 582	1995	1.8	3.0	-	-	✓	The variety was grown under harsh conditions
8. Arman Ali	Rajshahi	Parmanandpur	BRRIdhan 28	Sugandha 1	333	3.9	4.2	4	2	✓	
9. Kurban Ali	Rajshahi	Parmonandpur	BRRIdhan 28	Judi582	865	4.5	6.0	20		✓	Seed demand from the neighbours
10. Nazurul Islam	Rajshahi	Parmonandpur	Minikit	PNR 381	1663	4.2	6.0	75	15		Kurban Ali's father
11. Abdullahaziz		Digram	BRRIdhan 28	Judi 582	1663	4.2	6.0	15	1	✓	
Total					10407			414	67		

SDR= short duration rice; yield data are based on farmers' observations.

Nazzurul Islam, Chaubisnagar owns about 15 *bigha*[3] of land.

- He grew Pant Dhan 10 during the *boro* season and produced 405 kg from 3/4 of a *bigha* compared with a yield of 390 kg from the same area during the *t. aman* season. He knew that the lower yield in t. *aman* season was due to late planting. His neighbours who planted in time got better yields.
- He now knows a lot more about the quality traits of this variety, e.g. it has very good cooking and eating qualities, grains are medium fine.
- It also has drought tolerance hence requires less irrigation while BRRI varieties need 2-3 irrigations more than Pant Dhan 10. Irrigating one *bigha* land requires about Tk 90 ($ 1.6) per irrigation and this is also a saving in the case of short duration rice varieties. During the *boro* season there is generally a lack of diesel and electricity, this further complicates efforts to avoid subjecting longer-duration varieties to moisture stress. Pant Dhan 10 is safer as it is earlier.
- He mentioned that early maturity is also desirable as rice can escape potential damage from the storms and also pre-monsoon rain that may affect yield or quality of the produce or both.
- He also reckoned that Pant Dhan 10 requires nearly 50% less fertilizer compared to BRRI varieties with a saving of about Tk 120/*bigha ($ 2.1/bigha)*.
- Pant Dhan 10 is also easier to thresh and saves on threshing time even using the pedal thresher.
- He mentioned that during the *boro* season BRRI varieties tended to lodged heavily as they were taller causing considerable yield loss. Pant Dhan 10 with stiff straw did not lodge.
- 20 farmers already approached him for the seed. Of these, 12 took Pant Dhan 10, while 8 farmers took either Judi 582 or BG 1442.
- The grain expands on cooking
- It takes about 10-15 minutes less time than Swarna for cooking with important savings on fuel that is scarce.
- He put more emphasis on the early maturity of Pant Dhan 10 as it needs 100-110 days in the field (nearly 45 days in the nursery) during the *boro* season compared to 145 days for BRRIdhan 28 and 155 days for BRRIdhan 29.



Nazzural Islam with a sample of Pant Dhan 10 rice

Nazzurul said "I sold or exchanged over 100 kg of rice seed this year".
He intends to expand the area under new short duration rice varieties including Pant Dhan 10.

[3] *Bigha* is a local unit of measuring land in Bangladesh. 1 *bigha* = 1,330 m^2, 20 *kattha* = 1 *bigha* and 1 *kattha* = 66.5 m^2.

Md Rajob Ali (A), Chaubishanagar owns 15 *bigha* of land.

- He planted Pant Dhan 10 in 1 *bigha* land and harvested 16.5-*maund*/*bigha* rice, though he expected to have 20 *maund*/*bigha*. He thought that the weight of Pant Dhan 10 was less than Swarna which might explain the lower yield. From the same field last year, he harvested about 16 *maund*/*bigha* from Parija and 14 *maund*/*bigha* from BRRIdhan 28.
- He recalls that there was less rainfall, less cloudy sky and less insect attack. But yield levels were not very high and with this management BRRIdhan 28 may have given only 12-13 *maund*/*bigha*.
- His observation on the nutrient responsiveness of Pant Dhan 10 was that given the same amount of fertilizer as Parija and Nain muni, Pant Dhan 10 responded more.
- Since Pant Dhan 10 did not lodge, it was easier to harvest, as plants were standing erect. His experience had been that it is really cumbersome to harvest a lodged crop of rice.
- He was constantly keeping an eye on the market prices for various rice varieties and found that Minikit[4] variety was selling at Tk 310/*maund*($5.4 per 40 kg), Pant Dhan 10 at Tk 300/*maund* ($5.3 per 40 kg) and BRRIdhan 28 at TK 270/*maund*.
- His strategy, as he shared with the team, was that he wished to sell Pant Dhan 10 and consume a relatively coarser variety.
- He intended to grow Pant Dhan 10 during *t. aman* and find out more about the variety then he would decide on whether to grow this variety next year in the *boro* season.

Rajob Ali (A) with a sack of Judi 582

Arman Ali, Parmonandpur, Godagari cultivated 11 *bigha* of land of which he owned just 1 *bigha*, the rest was rented in.

- During t. a*man* he got 1 kg of Sugandha 1 seed from the project and planted in 5 *kattha* harvesting 2.25 *maunds*. He used some of the seeds for *boro* from the t. *aman* harvest and planted in 10 *kattha* and harvested 7 *maund*s.
- He was impressed with the grain and straw yields and the grain quality of this variety. The milling recovery of the rice was 60%.
- He found that the Pulao was a bit more sticky and hard but the steamed rice had very good flavour. He thought that this rice required much delicious curries to go with it and to him it seemed like a rich man's rice.

Arman Ali

- When this rice was cooked together with the chickpeas, it gives nicer taste. He gave 2 kg seeds each to two farmers during *t. aman* season.
- He intended to plant 5 kg seeds in 15 *kattha* of land all for his home consumption**.**

[4] Minikit is an unidentified variety from India, initially included in the Minikit programme and subsequently known by the same name as it lost its original identity.

Rossal, Godagari owns 18-*bigha* land

- He tried BG 1442 in a small patch of land (96 m^2) and harvested 75 kg rice.
- The variety was non-lodging
- He planned to grow 10 kg seed in *t.aus*, harvest the crop and use the same variety for t. *aman*. Following *t. aman* he would then grow chickpea. Hence he was planning to grow three crops of BG 1442 to exploit its early maturity.

Rossal - a farmer

Rojab Ali (B), Chuabishanagar owns 17 *bigha* of land.

- He grew Judi 582 in 5 *kattha* of land. He got 1 kg seed from PROVA during last *t. aman* season and harvested 75 kg and the same seed was used for planting during the *boro* season.
- It appeared that he was pretty satisfied with the performance of the variety and put it as "*sundar Dhan*" meaning beautiful rice in vernacular language. He made the following observations for this variety:
- There was no seedling mortality in the nursery under the foggy conditions as the variety was cold tolerant in the seedling stage. Under similar conditions, the seedling mortality for BRRIdhan 28 was quite high.
- *"Khara shahisnu Dhan"* means drought tolerant in vernacular language
- High yield: seeding was late, in spite of that the yield was quite high. Had other varieties been planted so late no reasonable harvest could be expected.
- It has more attractive grains and less chaffs compared to other *boro* varieties.
- Judi 582 is heavier in weight, an important criterion for the farmers.
- One of the unique observations by the farmer was that Judi 582 has an erect flag leaf and it extends quite close to the neck of panicle, i.e. neck of the panicle is short. He reckoned that this type of variety gives more yield compared to a variety having droopy flag leaves. BRRIdhan 28 seems to have drooping leaves with long neck of the panicle.
- Is early maturing
- It did not lodge even under adverse conditions (survived stormy winds) while BRRIdhan 28 did .

Rojab Ali (B) with his rice thresher.

Planted Judi 582 in a relatively less fertile land compared to BRRIdhan 28 and applied same amount of fertilizer but his observation was that it did well even under moderate fertility unlike BRRIdhan 28.

- Very uniform crop including synchronous flowering.
- Required less cooking time compared to BRRIdhan 28
- Better quality of *bhat* than BRRIdhan 28.
- Even *basi bhat* (stale rice, i.e. eaten considerable time after cooking!) is reasonably good while *basi bhat* of Minikit does not taste as good. Market price TK 300/*maund* similar to Parija
- No one had asked for seed of this variety yet.
- For Pant Dhan 10, more than 20 farmers came for seed and he bartered or sold about 100 kg when told the selling price was Tk 400/*maund ($ 7.0 per 40 kg).*
- His plan for the coming season was to reduce area under BRRI varieties and increase area for new SDR varieties. He clearly mentioned that he wanted to diversify varieties to spread the risk

***Soyjuddin, Godagari* owns** 15 *bigha* of land.

- He got 1 kg seed of Pant Dhan 10 as a Baby trial from the project last year *t. aman*, harvested 50 kg and used part of that harvest to grow in 2 *bigha* of land in *boro* season.
- He planted the crop late during *boro* season. Looking at the crop he expected 18-20 *maund/bigha* but he actually harvested 17 *maund/bigha*.
- The yield from Nain muni variety was only 12-13 *maund/bigha* while Minikit variety gave a yield of 14 *maund/bigha*.
- He mentioned that the flowering stage of Pant Dhan 10 met with a storm resulting in severe dropping of the flowers and ultimately a reduction in yield.
- The variety did not lodge and there was no yield loss from lodging
- Price of Pant Dhan 10 was same as Minikit or Parija.
- He intended to grow Pant Dhan 10 again in 2-*bigha* land during *t. aman*.
- 7-8 farmers have already taken the seed (about 10-15 kg per farmer). He felt that in a few years time most of the Godagari area would come under Pant Dhan 10.

Lutfar Rahman, Nabogram cultivated 12 *bigha* of land, of which 2 *bigha* belonged to him while he rented 10 *bigha*.

- He planted Judi 582 in 1.5 *bigha* and harvested 10 *maund*s. The crop was totally rainfed and experienced drought; even then it gave reasonable yield.
- He reckoned that other varieties would have just given 5-6 *maund*s under such harsh conditions, however, Judi 582 was better.
- He also planted BRRIdhan 28 and Parija which gave a yield of 6 *maund*s each *bigha*.
- He saw the difference within the Judi 582 crop stand; particularly in the patches where there was more moisture he found better performance.
- He intended to grow this variety in 4 *bigha* in *t.* a*man* season. It was learnt that the seedlings were raised at Parmanandpur, Godagari and carried about 20 km? to Nabogram for transplanting.

Lutfar Rahman

- He has yet to test the post harvest qualities, e.g., milling recovery and taste of *bhat*, etc, but without going for those he was pretty convinced and he intended to grow it in the coming season

Rabi Tudu and Srimati Tudu (Husband and wife), Chaubishnagar, **Chaighati** are landless farmers from a tribal ethnic group of Bangladesh, but cultivate about 3 *bigha* of land on a contract agreement at 3 *maund*/*bigha*.

- They planted Pant Dhan 10 in 15 *kattha* and harvested 12.5 *maund* (16.5 *maund*/*bigha*), which was more than both BRRIdhan 28 and Parija that gave about 12-13 *maunds bigha*.
- They reckoned that Pant Dhan 10 yields higher with the same amount of fertilizer and less water. Rabi also remarked that the variety had "*khara Sahishnu"* trait, i.e. drought tolerance.
- They did not come across any insect or disease problems on Pant Dhan 10. They were planning to grow Pant Dhan 10 in their entire contracted field in t. *aman* season.
- Another interesting point which Rabi Tudu shared with the team was that they kept Pant Dhan 10 for seed and home consumption while gave Parija to the owner and this was because they very much preferred the quality of this variety.
- Another remark made by them was that all the *boro* rice varieties that were in the village lodged but this did not lodge.
- Until now, two farmers have approached them for seed, one has already taken 10 kg while another asked for 20 kg but has not yet bought it.
- Another farmer (Rup Lal) who was listening to the discussion was pretty convinced and placed an order for seed with Rabi.

Rabi Tudu

Srimati Tudu

Kurban Ali, Parmanandpur owns 9-bigha land.

- He got 1 kg seed of Judi 582 in *t. aman*, season from the project and used the harvest from *t. aman* to plant in 13 *kattha* of *boro* crop harvesting 13 *maund*, about 20 *maund*/*bigha*. Whereas Minikit gave only 15 *maund*/*bigha*. In the coming season he wished to grow Judi 582 in 5 *bigha*.
- He found this new variety similar to Minikit in most traits, e.g. fertilizer requirement, tolerance to insect pests and diseases while Judi 582 was nearly 20 days earlier than Minikit variety and much higher yielding. He also knew about the quality traits of Judi 582, e.g. finer grains than BRRIdhan 28, good milling recovery with no or less breakage and moreover the quality of *bhat* was good. It also required less cooking time than BRRIdhan 28.

Kurban's observations on Judi 582:

- It has better seedling vigour
- Medium height with stiffer plants and hence does not lodge
- It has better cold tolerance at seedling stage than BRRIdhan 28, as the mortality of the latter was quite high in the nursery.
- There was already 20 kg seed demand from the neighbours although not yet purchased.

Kurban Ali with his wife busy in post harvest operations

- Kurban Ali also planted PNR 381 in 25 *kattha* and harvested 23 *maund*s. This was also given the similar management as for Judi 582 and Minikit variety.

Kurban's observations on PNR 381:

- It appeared that PNR 381 may require less fertilizer than other varieties. It gave good yield even under partially irrigated condition.
- Was later than Judi 582 but same as Minikit
- Got good yield with moderate care and maintenance
- He sold a total of 75 kg PNR 381 seed to 15 farmers.

Abdullahaziz, Digram owns 50 *bigha* of land. He got 1 kg of Judi 582 in a Baby trial from the project, harvested 50 kg and from that harvest, he planted this variety in 25 *Kattha* in *boro*.

- Although transplantation of the crop was late due to the shortage of electricity, he harvested a reasonable yield, i.e. 16.5 *maund*/ *bigha*, while other varieties gave 14 *maund* from a similar area.
- He clearly noticed that this variety had '*Khara Sahisnu*' trait i.e. drought tolerant.
- Its fertilizer requirement may be the same, but because of late planting it attracted more insect pests. He also noticed that other varieties lodged but this did not.
- The market price of Judi 582 was Tk300/*maund(*$ *5.3 per 40 kg)* compared Tk280/*maund* ($ 4.9 per 40 kg) for most of the varieties and Tk 305/*maund* ($ 5.4 per 40 kg) for Minikit.
- He was willing to grow this variety during the coming *t.aman* season. Somebody came and purchased 15 kg seeds of this variety from him. This he considered as a sign of success of this variety.

The team also came across an interesting case while discussing with Abdullahaziz, another farmer Abdul Kalam Azad, in the same village had developed a crop museum (i.e. collection of varieties) with 11 *boro* rice varieties in which Judi 582 was also included. It was learnt that;

- The crop museum was actually planted on rented land (rented 2.5 *bigha*).
- Of the 11 varieties, the highest yield of 4 t ha^{-1} was obtained from Judi 582.
- A ranking exercise by the farmers was also done and Judi 582 followed by Minikit was the most preferred varieties.
- He intended to grow Judi 582 on about 10 *kattha* of land during the coming *t. aman*.

Conclusions from in depth studies

In spite of the very limited time spent in the community our discussions with the farmers revealed some very interesting information which is summarised below.

- Overall, SDRs out-yielded all the existing *boro* rice varieties by 32%.
- The yield advantage with Judi 582 was 37% and with Pant Dhan 10 over 29%.
- SDRs were considered '*khara sahinshu'*, i.e. drought tolerant by the participating farmers. There was a saving of 2-3 irrigations with SDRs as they mature earlier and had more drought tolerance.
- Judi 582 was also considered to have cold tolerance and better seedling vigour.
- SDR varieties did not lodge.
- SDRs were considered to require less fertilizer and were more responsive to the applied inputs.
- SDRs have better grain quality, required less cooking time and taste better.
- SDRs fetch a comparable price in the market with that of the best selling *boro* variety, e.g. Minikit.
- All the farmers intended to grow them in the coming *t.aman* season. There was evidence of seed sale and exchange taking place in the community. These are the indicators of uptake and adoption of SDRs in HBT area.

WAY FORWARD

- The significant findings of this study should be shared with government organizations (GOs), non-government organizations (NGOs), community based organizations (CBOs), Consultative Group on International Agricultural Research (CGIAR) systems and donor communities working on rice research and development in Bangladesh. This wider collaboration will aid the scaling up of farmer-preferred technologies in order to promote more widely the benefits of the most promising rice varieties.
- As part of this process a workshop has been organized in October 2004.
- This study suggests that the SDR varieties are suitable for both the *t. aman* and *boro* seasons and quite likely beyond the HBT as well. There is a need to have

systematic evaluation of these varieties across domains in different seasons and outside the HBT area.

- It is proposed that efforts are made to initiate policy dialogue with the GO sector in Bangladesh to explore the possibility of institutionalizing the process and outputs of this initiative into the formal sector.

ACKNOWLEDGEMENTS

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ANNEX 1: *General climatic conditions and rice planting operations in 2003*

Rainfall pattern during the rainy season of 2003 in different parts of HBT, Bangladesh was variable and unreliable. There were also cases of unusually high rainfall in October when it was not so important for crops (Fig. A). Severe drought occurred from the last week of July through the whole of the August in Godagari. Similarly little rain fell in Porsha during August.

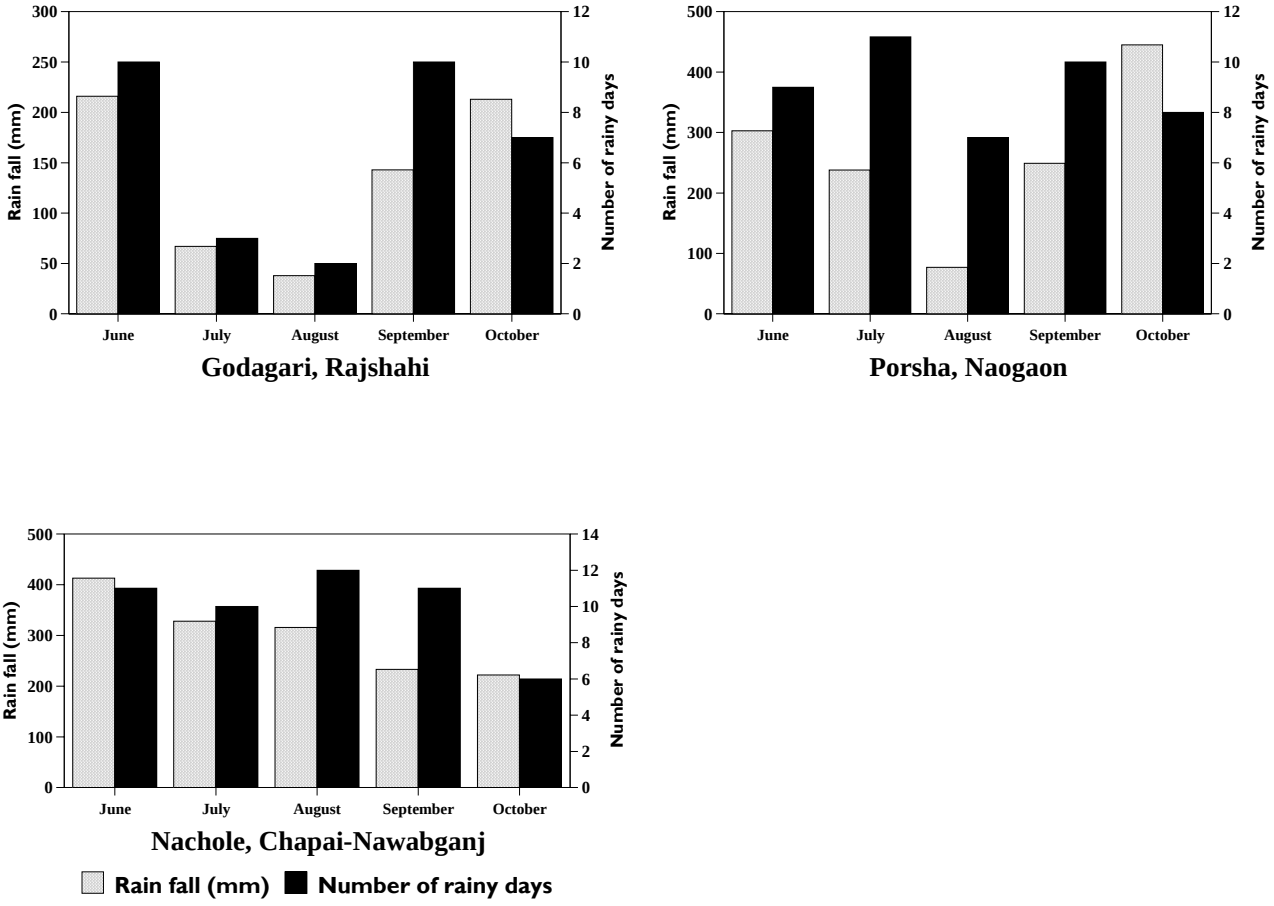

Figure A. **Amount and distribution of rainfall at three upozilla of High Barind Tract of Bangladesh, 2003**

Rice transplanting in HBT area started from the third week of July and continued until the middle of August (Fig. B). There was considerable difference in the timing of seeding and planting rice so that the age of seedlings differed quite markedly between Porsha, Godagari and Nachole. In the latter two upozilla, rice seeding and planting generally started much earlier than at Porsha.

The rice crop in general in the HBT area suffered from moisture stress both in the nursery bed and in the field. Because of severe drought much of the land in the Porsha area also remained fallow.

Seeding and planting time for rice in High Barind Tract (HBT), Bangladesh, September 03

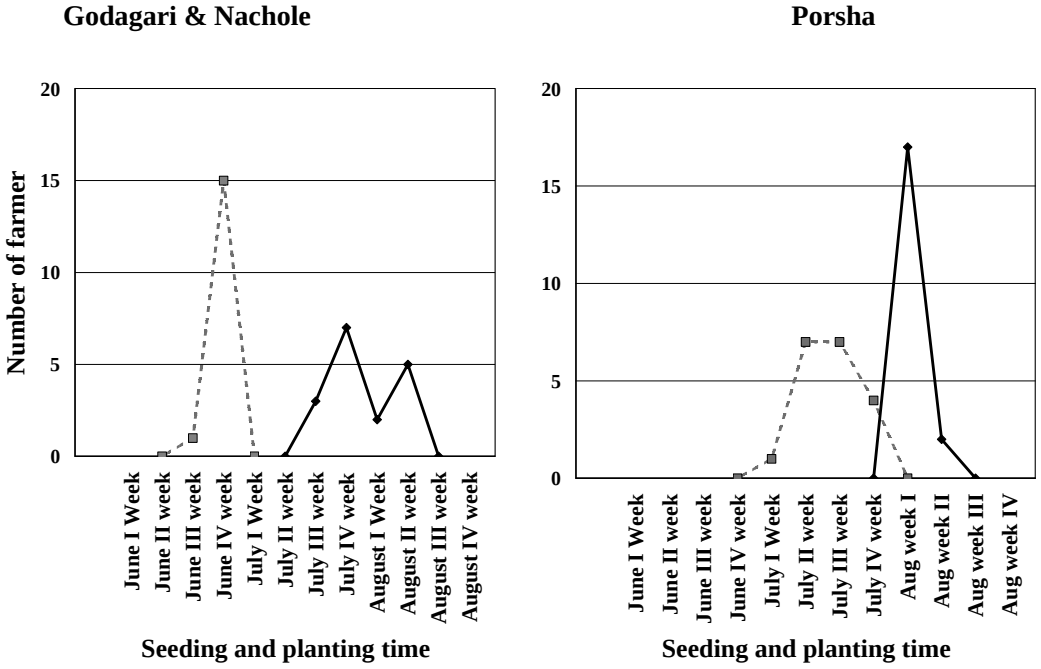

Figure B. **Date of seeding (dotted lines) and transplanting (solid lines) of rice in the High Barind Tract (HBT) of Bangladesh, 2003.**

ANNEX 2: *Community-based seed production*

Table A. Summary of community based seed production by PROVA in the High Barind Tract of Bangladesh, 2003

Rice variety	***Quantity of Seed (kg)***
Pant Dhan 10	1223
PNR 381	44
Ekhattar	27
Sugandha 1	189
Judi 582	323
Judi 565	22
Judi 566	23
Judi 567	28
Barkhe 2001	135
Sarwati	60
BG 1442	133
Swarna	40
BRRIdhan 32	32
BRRIdhan 39	45
BRRIdhan 40	20

Institutionalisation of the outputs of a participatory crop improvement project in Gujarat, India

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ABSTRACT

A participatory crop improvement (PCI) project in Gujarat, India targeted the high potential production system (HPPS) devoted largely to rice and wheat. An NGO, the Action for Social Advancement (ASA), led this project. A new rice variety that was not officially recommended for cultivation in Gujarat greatly reduced farmers' costs of production and has spread widely. Several institutional impacts followed from the project. ASA is now leading projects that are based on the PCI approach, and has recognized the need for changes in regulatory frameworks that control the release and popularization of varieties. ASA is now beginning to actively advocate such changes.

INTRODUCTION

The Action for Social Advancement (ASA), has worked in collaboration with the Centre for Arid Zone Studies on a participatory crop improvement (PCI) project in Western India. The aim of the project was to improve agricultural productivity of smallholder farming systems in the Godhra district of Gujarat by providing farmers with a 'basket of choices' in relation to crop cultivars and production technologies. As an example of the success of the approach we describe the value of the rice variety *Mahamaya*, identified by the project, to the farmers. ASA became convinced by these successes and has begun a process of institutional uptake.

IMPACT IN INDIA

Why is participatory crop improvement needed?

It is commonly assumed that farmers in high potential production systems (HPPSs) have much better access to modern technologies than those in marginal environments. However, huge variation exists in the HPPSs and in many regions old varieties still dominate cultivation, suggesting that farmers are failing to benefit fully from modern plant breeding products. For example, in Godhra district, farm households have been growing one single variety of rice, *GR 17* in over 90-95 % of the irrigated rice area for over a decade. The variety is in very high demand and so fetches a premium over other rice varieties. However, the variety has, over time, lost much of its resistance to pests and now requires high pesticide applications which have raised the cost of production.

A higher yielding, farmer-preferred rice variety for irrigated conditions

The participatory varietal selection (PVS) programme identified a new rice variety, *Mahamaya*, for cultivation in HPPSs. This variety has been released in several states of India, but not in Gujarat and is much higher yielding than the local cultivar, *GR 17* (Fig. 1). The increase in yield is largely due to the shorter duration of *Mahamaya* (ca. 10 days) which reduces its vulnerability to end-of-season drought.

Farmers place great importance on early maturity as it brings many added benefits, including lower costs of production. By harvesting earlier, the next crop (usually wheat) can be sown on residual moisture, thereby saving on pre-sowing irrigation. *Mahamaya* is also more resistant to pests and diseases and so requires fewer chemicals. This has both financial and environmental benefits. Overall, *Mahamaya* resulted in a net saving of 25% compared with the recommended *GR 17* cultivar (Fig. 2).

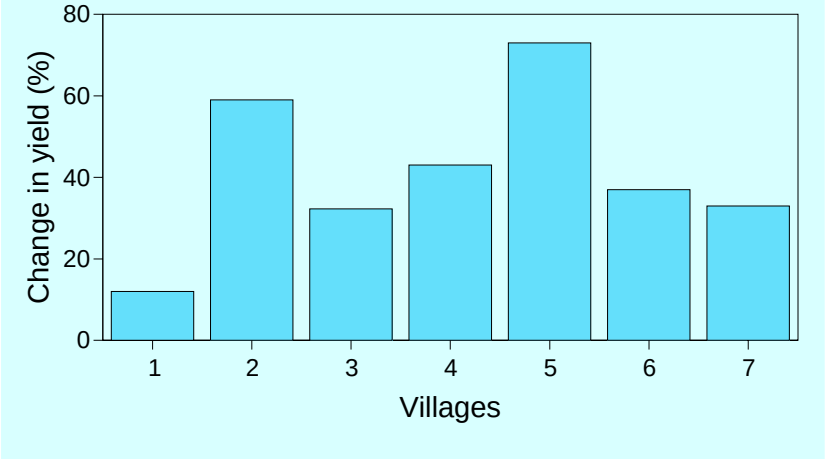

***Figure 1*. Percentage yield gains due to the introduction of the new rice variety *Mahamaya* relative to the cultivar GR 17. Data are the mean of 36 farmers in each village.**

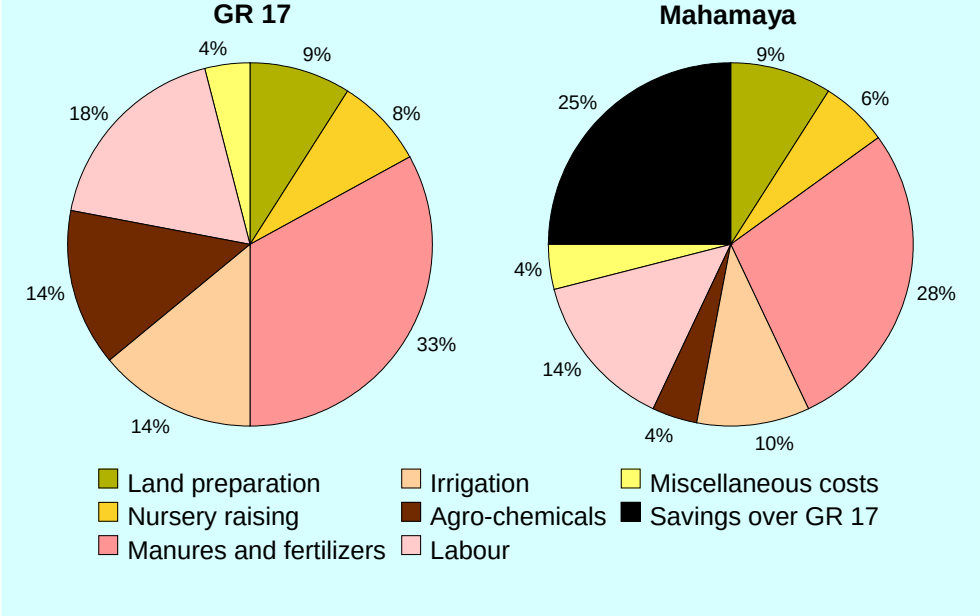

***Figure 2*. Percentage costs of production for GR 17 (local cultivar), and *Mahamaya* (PVS variety), Gujarat, India 2003.**

This, and other successful examples, convinced ASA and its partners that the PCI approach was simple, effective and worthy of wider adoption. We examine how this approach is in the process of vertical dissemination and institutionalisation.

Institutionalisation of project outputs

One important institutional mechanism that has been created by the PCI project is a seed producers' cooperative. This cooperative supplies seed of farmer-preferred varieties to farmers in the region and continues to do so following the official end of the project in January 2003.

In addition to the seed cooperative, some individuals have also started to supply seed within the region. For example, a local man who had worked as a research associate for the PCI project has undertaken seed multiplication of the one of the preferred rice varieties, *Mahamaya*, introduced by the PCI project. He has procured about 20 t of seed to be sold in the next season. According to him, there is an increasing demand for the variety in the area and he predicts that in the next 3 to 4 years *Mahamaya* will become the dominant local variety. He has developed a business plan to produce and sell at least 200 t of seed in the next two years and all these activities will be undertaken at his own cost. He has requested support from ASA to develop links with the research institutions for access to seed of new varieties and plans to use this seed to conduct PVS trials to identify new genotypes for future business.

Institutionalisation of PVS within ASA has also taken place. ASA is currently working in watershed and participatory irrigation management projects in four districts of Madhya Pradesh, encompassing more than 100 villages and is now using PVS trials as a regular intervention. Concurrently, ASA has submitted a proposal to a DFID supported project in Madhya Pradesh which provides support to NGOs for civil society strengthening. The core element of ASA's proposal to DFID is to provide capacity building support to at least 15 NGOs from within the existing grantees for establishment of PVS trials.

On a wider scale, ASA has also begun several initiatives to institutionalise PVS approaches within government projects and quasi-government organizations. One example is an ASA assignment to provide technical inputs to a World Bank project 'District Poverty Initiatives' together with the government of Madhya Pradesh. The project is working in 2000 villages in 14 districts of Madhya Pradesh. ASA input includes the setting up of PVS trials in about 60 villages across three project districts. These PVS trials have proved extremely successful in demonstrating the utility of PVS as well as capacity building in terms of training and gaining the trust of project personnel. The success of these trials means that it is likely that PVS will be adopted in all 14 project districts covering the 2000 villages.

A clear constraint to the PVS approach is the current regulatory framework that makes it practically impossible for an NGO or project to gain official recognition of the suitability of a variety for cultivation. In order to promote a policy for positive changes in the seed regulatory framework ASA is planning a number of workshops and preparing review/discussion papers to engage the policy makers in the coming years. Policy changes arising from such initiatives will take time, but the case will be strengthened by exposing more and more organizations to the benefits of PVS and building their capacity to participate.

Participatory crop improvement in Eastern India: An impact assessment

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ABSTRACT

DFID-PSP has funded Participatory Plant Breeding (PPB) in rice in eastern India. The project was jointly undertaken by the Gramin Vikas Trust Eastern India Rainfed Farming Project (GVT(E)), Birsa Agricultural University (BAU), Ranchi and the Centre for Arid Zone Studies (CAZS) University of Wales, Bangor, UK.

As the result of PPB, two varieties of rice (Ashoka 200F and Ashoka 228) were officially recommended for upland rainfed farming systems in Jharkhand. Surveys were undertaken in 2002 and 2004 to determine their impact on the livelihoods of farmers in eastern India.

Farmer preference for the new varieties was high. For example, in 2002 about 97% of farmers indicated that they would grow the new varieties next year, and 90%, or more, farmers perceived them to be higher yielding, and have a higher market price in both the 2002 and 2004 surveys. The price advantage was 33% in two of the three states and overall it was 14% in the 2004 survey. In both years, most farmers also perceived the new varieties to be earlier, higher yielding, more resistant to drought and lodging.

The new varieties significantly improved household income, with a large proportion reporting that the effect on income was large. In the 2004 survey, nearly 70% of farmers reported increases in on-farm income of at least 20%. A financial analysis, using very conservative assumptions for the adoption ceilings of the new rice varieties indicate, in all scenarios, that the cumulative benefits from this project will be greater than the total expenditure on the Plant Sciences Research Programme 1995-2005. The only variable is how quickly this will be achieved and estimates centre around 2010.

Seed multiplication is being undertaken by a range of non-governmental and governmental organisations to meet the high demand for seed. A seed multiplication and dissemination programme is also underway in western India where the varieties have also proven to be highly accepted by farmers.

INTRODUCTION

Poor farmers in marginal areas have benefited little from high yielding, 'green revolution' varieties that have transformed the productivity of more favourable areas. Hence in the states of north eastern India, farmers who cultivate upland rice on low-fertility, sloping soils continue to grow low-yielding landraces that are susceptibility to diseases and pests. Participatory plant breeding (PPB) in such areas offered a rapid, cost effective solution to these problems by developing varieties superior to these landraces.

In May 2001, the Birsa Agricultural University (BAU) in Jharkhand, eastern India, released the first-ever early maturing, high yielding, superfine rice varieties for rainfed uplands. They were the products of a highly successful PPB programme. They were bred during a collaborative project, which has been operating since 1997, between the Gramin Vikas Trust East (GVT(E)) in Ranchi, Jharkhand, India, BAU, and the Centre for Arid Zone Studies, Bangor, Wales. Surveys were undertaken of adopting farmers in 2002 and 2004 to estimate the impact of these varieties.

IMPACT IN INDIA

Background

Farmers of rainfed uplands require early varieties that escape end-of-season drought but still give a good yield of grain and fodder. Using participatory varietal selection (PVS), GVT(E) gave farmers a choice of upland varieties and they identified Kalinga III, a rice variety that, despite its advantages of early maturity, high grain and fodder yield and good cooking quality, had limited adoption because of its poor inherent resistance to drought. Kalinga III was improved by using it as a parent in a cross in a PPB programme. The result was two outstanding rice varieties (Ashoka 200F and Ashoka 228).

We describe here the results of surveys of farmers in 2002 and 2004 that assessed the impact of these varieties.

Methods

The impact of the two rice varieties (Ashoka 200F and Ashoka 228) was studied in villages where seed had been distributed either directly or indirectly by GVT(E). In 2002, about 15% of the households were randomly sampled from the 1000 that received seed from the GVT(E). There were 126 sample households[1] from the GVT(E) villages and farmers from these households were interviewed using a semi-structured format. In 2004, several hundred households were surveyed. We include here an analysis of the first 36 households[2] to have been interviewed.

[1] 56 in Jharkhand, 29 in Orissa, and 41 in W. Bengal. Included 23 households who received seed through NGOs, and 10 from those who received seed through the state department of agriculture.
[2] 7 in Jharkhand, 15 in West Bengal and 14 in Orissa.

Seed transactions

2002 survey. Farmers sold between 2 and 2000 kg of seed to farmers within the villages but also outside the villages up to a distance of 300 km (Table 1). The spread of seed was through relatives and friends. For example, from Haldikundi village, the seed spread as far as 60 km.

Table 1. **Range of amount of seed sold by farmers and range of distance of spread from the seed foci in *kharif* 2002.**

Variety	Orissa		West Bengal		Jharkhand	
	Amount (kg)	Distance (km)	Amount (kg)	Distance (km)	Amount (kg)	Distance (km)
Ashoka 228	10-2000	12-300	2-30	1-15	10-120	0.5-3
Ashoka 200F	10-900	11-20	10-20	11-20	25-200	-
No. farmers Sampled	38		45		76	

2004 survey. On average each farmer distributed seed to nearly one other farmer. The surveyed farmers reported a spread for 2003 to 2004 that was as high as that reported for 2002 to 2003, despite the fact that most farmers ask for seed nearer to the sowing time in June or July. The average amount of seed sold, gifted or exchanged per farmer was over 20 kg in both years.

It is important to note that this survey was of farmers that had been adopters for several years and have good contact with the GVT(E) project. They are, therefore, less likely to distribute seed than 'non-project' farmers, because project farmers can always ask the project for more seed while non-project farmers supply seed to other farmers to ensure a seed supply.

Farmers' perceptions of the new varieties

In the surveys of 2002 and 2004, the great majority of farmers perceived that, compared with local cultivars, the new varieties were higher yielding and had better quality grain with a higher market price (Table 2). These slender-grained varieties were easier to market and fetched a higher grain price than the local, coarse-grained varieties. In the 2004 survey, the price advantage averaged 14% (Rs 7.45 for the Ashoka varieties compared to Rs 6.1 for the local variety). In Jharkhand and Orissa the price advantage was much higher (33%) and the low average resulted from only a 6% advantage in West Bengal where farmers commonly grew the higher value Kalinga III.

Most farmers report that the new varieties have better drought tolerance. They certainly performed well during the extreme drought of 2002. In the worst drought hit area of Kalahandi district, Orissa, the Deputy Director of Agriculture reported that the performance of Ashoka 228 (Ashoka 200F was not tested) was outstanding even when the local varieties had failed.

The extent of agreement between the 2002 and 2004 surveys is extremely impressive, more so considering that data were collected independently by different surveyors and for different

samples. This can only add to the level of confidence that can be placed on the acceptability of the new varieties and their projected substantial adoption.

Table 2. **Farmers' perception (expressed as % of farmers) of Ashoka 228 and Ashoka 200F rice varieties in comparison to the local cultivars. Based on a survey of 159 households sampled over all three states (Orissa, Jharkhand, West Bengal) in December 2002, and 36 households in February 2004.**

	2002[1]			2004[1]		
Trait	**Ashoka preferred**	**Local preferred**	**Same**	**Ashoka preferred**	**Local preferred**	**Same**
Grain yield	92	2	5	95	0	5
Straw yield	68	5	25	76	0	24
Maturity	87	4	6	88	7	5
Drought tolerance	82	1	14	67 [2]	0	0
Weed suppression	69	1	28	-	-	-
Market price	89	0	10	90	0	10
Eating quality	82	2	12	90	0	10
Overall preference	91	1	6	-	-	-
Which variety would you prefer to grow again?	97	3	0	100	0	0

[1] The total may not be 100 as the 'no response' class was omitted.
[2] Perception based on only those farmers who reported it as an additional property of Ashoka varieties.
- Not recorded in 2004.

Adoption

An increasing trend in the area of cultivation of the two varieties was found (Fig. 1). In the first survey, the adoption percentages projected for 2003 were high (Fig. 1), certainly in part due to errors involved in asking farmers for projections. Nonetheless, it was clear that adoption increased at a fast rate and eventually adoption ceilings of 100% of upland rice area are likely. This was confirmed by the 2004 survey data where overall adoption in 2003 was on average ca. 60% with anticipated further increases in 2004.

Further increases in area of adoption are expected in 2004 and beyond. These increases will be much more substantial because of the acceptance of these varieties elsewhere in the country. The GVT Western India Rainfed Farming Project (GVT(W)) has tested the two new varieties in participatory trials in Gujarat, Rajasthan and western Madhya Pradesh along with a range of promising upland varieties from many sources. In trials in Rajasthan in 2003, 86% of farmers in 30 trials preferred the Ashoka variety. In all three states, the two Ashoka lines were the most preferred overall in the trials for their high yield combined with earliness and better grain quality.

GVT(W) already has an active seed multiplication and distribution programme for these varieties.

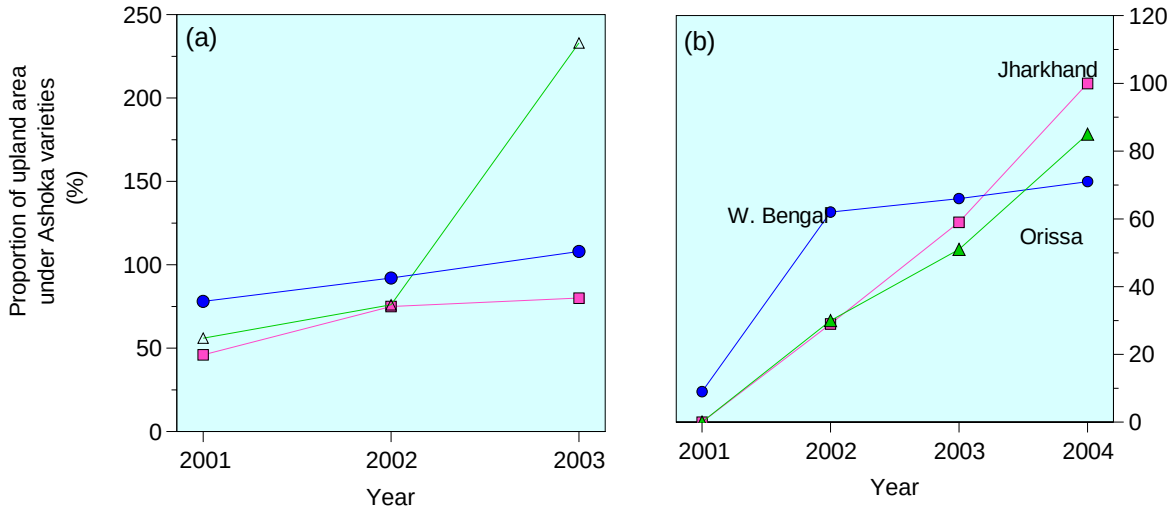

Figure 1. **Increase in cultivated area of the new rice varieties: (a) 2001 to 2002 and projected area for 2003. Based on survey in Dec 2002; Orissa (N = 38), West Bengal (N = 45) and Jharkhand (N =76); (b) 2001 to 2003 and projected area for 2004. Based on survey in Feb 2004; Orissa (N = 14), West Bengal (N = 15) and Jharkhand (N =7).**

Effect on livelihoods

In the 2002 survey, the new varieties had a significant effect on the household income (Table 3). The majority of farmers indicated small or large effects of the new varieties on the overall income of the households. More detailed questions were asked in the 2004 survey to quantify the impact on livelihoods in terms of rice sufficiency and increase in on-farm income (Tables 4 and 5). For farmers who were adopting the Ashoka varieties there was a considerable increase in rice availability: rice lasted 2-3 months longer and average sales per household more than trebled. In the 2004 survey, nearly 70% of farmers reported increases in on-farm income of at least 20%. Thus, the two surveys show that the new varieties contribute significantly to the improvement of livelihoods of poor farmers.

Table 3. **Impact of new varieties on overall income based on survey in December 2002.**

Size of impact on overall income	**Ashoka 228 (% of 103 interviewed farmers)**	**Ashoka 200F (% of 56 interviewed farmers)**
Tiny	23	9
Small	46	56
Large	29	34

Table 4. **Impact of new varieties on availability of rice for selling and consumption based on survey in February 2004.**

		Rice sold (kg)		Rice lasts (months)	
State	**N**	**Before**	**After**	**Before**	**After**
Jharkhand	7	0	4	9	12
West Bengal	15	43	72	6	9
Orissa	14	108	454	9	11
Overall	36	60	207	8	10

Table 5. **Impact of new varieties of rice on overall livelihood improvement (% increase in overall household income) based on survey in February 2004.**

State	**N**	**<10%**	**10-20%**	**20-30%**	**30-40%**	**>40%**
Jharkhand	7	43	14	29	14	0
West Bengal	15	0	13	27	33	27
Orissa	14	0	14	29	29	21
Overall	36	14	19	28	19	19

Seed production and sales

This is not just an excellent new technology but it is also in demand as there is a large area of uplands presently under landraces. As a result of the superior performance of Ashoka 200F and Ashoka 228, there is now a high demand for seed of the new varieties. Community based organisations, small scale seed entrepreneurs, GVT(E), BAU and State Departments of Agriculture are all involved in multiplication of the seed.

Self-help groups of farmers in villages in Orissa produced seed in the 2001 – 2002 off-season. The majority of this seed was procured by GVT(E) and distributed to farmers in more than 600 villages (Table 6) and to other agencies in the *kharif* (rainy season) 2002. It was also distributed to NGOs and state department of agriculture working in the Jharkhand, Orissa and W. Bengal states.

***Table 6*. Seed distribution (tonnes) by GVT(E) in the project villages in *kharif* 2002**

State	Ashoka 228	Ashoka 200F
Orissa	29	11
Jharkhand	26	11
West Bengal	3	-
Total	58	22

For the 2003 season, GVT(E) distributed seed in Jharkhand to the Jharkhand Government and to BAU, as well as to 6 NGOs and one private seed grower. In Orissa seed was distributed to the Department of Agriculture in four locations and to at least four NGOs.

Quantifying the impact

The population of people living below the poverty line in India is greatest in the eastern states. Rice is the most important crop in the region, and the majority of this rice is cultivated in upland, or medium upland to which the Ashoka varieties are adapted.

It is remarkable how well accepted the Ashoka varieties are compared to the traditional landraces or other modern varieties, and their superior performance under drought as well as in better conditions greatly reduces the uncertainty of the forecasts on their impact. It is of significance that the two new varieties performed very well in the extreme drought year of 2002. This means that adoption trends will be less affected by the most important external shock in the upland rice growing areas, namely drought. In many places, the surveys showed that the local cultivars had failed but the new varieties survived the drought. In some places such as Bhirbhum (W. Bengal), the seed crop of Ashoka 228 totally wilted due to drought. However, a little rain around the middle of August enabled it to recover and produce a bumper crop. In the worst drought hit area of Kalahandi district in Orissa the Deputy Director of Agriculture reported the outstanding performance of Ashoka 228 when the local varieties had failed.

A financial analysis was made of the benefits that these varieties, in just three states (Jharkhand, Orissa and West Bengal), can bring (Fig. 2) using the assumptions in the box (next page). The benefits are large and anticipated cumulative benefits from this project by 2010 will be greater than the total expenditure of £19.5 million on the Plant Sciences Research Programme 1995-2005.

The benefit/cost ratio of this research is very favourable, even assuming a higher than actual annual cost of research of £100,000. The benefits of this research have to be shared between the NR Strategy and the DFID India desk, as donors, and between CAZS, GVT(E) and BAU as the project implementers. The benefits are sufficiently substantial for credit sharing.

Assumptions

- Reference year of 2002 with a research expenditure of £0.5 million by that year and a further annual expenditure of £100,000 for research and development.
- A two-fold rate of spread in all three states.
- An adoption ceiling of 40% of the upland rice area.
- An increased benefit per hectare from Ashoka 200F and Ashoka 228 of £33 per hectare (500 kg additional yield at £0.09 kg^{-1}).
- Projects supplies seed sufficient to sow 1600 ha in the first two years (the actual amount for 2002 and 2003). In 2004 this halves to 800 ha, in 2005 it halves again to 400 ha and remains constant until 2010 when formal seed supply is assumed to stop.

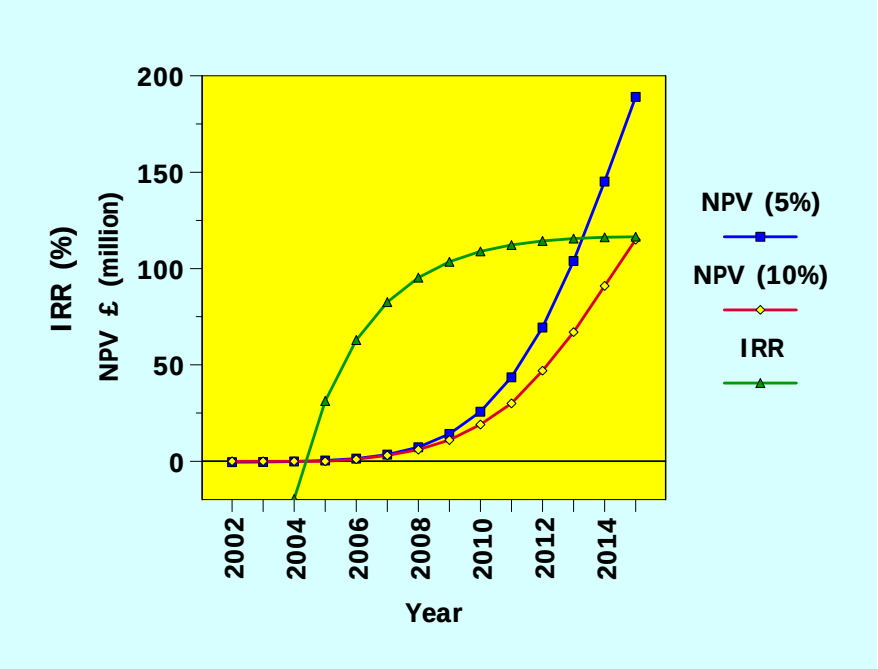

Figure 2. **Net Present Value (NPV) and Internal Rate of Return (IRR) over time from the new rice varieties using the assumptions described in the box above.**

Moreover, if less conservative (and hence probably more realistic) assumptions are made, the benefits increase greatly. What is clear is that the benefits from these varieties are always large (and reliably so) because there is no question that they are highly accepted and that they give a higher yield with an improved market price. Hence, it would not be at all unreasonable to assume that an adoption ceiling of up to about 70% will be achieved. The major variable is how quickly that ceiling will be reached: the question is not whether the benefits will be large but how quickly substantial benefits will be achieved.

All of our scenarios also ignore the benefits from:

- adoption in western India that will be substantial,
- the likely partial replacement of Ashoka 200F and Ashoka 228 with superior varieties that are emerging from the PPB programme in eastern India. New varieties developed through Marker Assisted Backcrossing (MABC) for better root growth have up to 25% more yield

with superior grain quality and better drought resistance compared to the coarse-grained, released varieties Vandana and BG 102 or the slender-grained variety Kalinga III.

Community-based breeding of superior, mosaic disease-resistant cassava in Ghana

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SUMMARY

Participatory cassava breeding is being done with two communities in Ghana; at Nkaakom in the forest zone and at Aworowa in the forest transition zone. The collaboration required a team of scientists and was initiated with village surveys on cassava production, consumption and marketing, followed by interviews of other cassava stakeholders from University researchers to private-sector processors. Cassava seeds obtained from superior, cassava mosaic disease-resistant landraces and varieties were direct-planted in communal plots. Scientists monitored growth and any pest and disease attacks monthly until harvest one year later. Farmers monitored crop growth informally and during field days. At harvest, many of the seedlings yielded several times the national average yield and many remained free of cassava mosaic disease (Fig. 1). Both farmers and scientists selected plants to provide cuttings for further trials: about 60% of the selections of the plant breeder and the farmers were in common.

Figure 1. **Farmers in Aworowa displaying the tuberous root yield of a selected cassava plant.**

INTRODUCTION

Cassava is grown throughout sub-Saharan Africa and increasingly is the main starch staple, particularly in West and Central Africa. An estimated $94x10^6$ t of the tuberous roots were produced in Africa in 2001 with $8x10^6$ MT in Ghana alone Cassava is also a raw material for food industries, livestock feed and a source of starch for chemical industries. However, pests and diseases, particularly cassava mosaic disease, are a major constraint. High-yielding, station-bred, cassava varieties have had limited uptake in much of Africa, including Ghana.

The project therefore has two main aims:

1. To develop an effective means of breeding new cassava varieties which are high yielding, pest (particularly cassava mosaic disease) resistant and acceptable to Ghanaian farmers, through involving farmers from the earliest stages of selection.
2. To understand how cassava landraces developed. This is being done by investigating farmer attitudes and practices regarding seedlings and should facilitate farmer involvement in cassava breeding.

The project is a collaboration between NRI, CRI and IITA[1], and required a multidisciplinary approach. Consequently, a team was put together consisting of NRI and CRI scientists covering agronomy, plant pathology (particularly virology), plant breeding and socioeconomics. The team identified two communities with which the project would work. These were Nkaakom, located in the forest zone, and Aworowa, in the forest/savannah transition zone (Fig. 2). Cassava is an important crop for both communities, and both have good access to markets, perhaps making them more able to utilise new ideas and cultivars.

Situation analyses and stakeholder survey

We began by analysing the current situations in Nkaakom and Aworowa, notably:

- The development of each community, particularly the introduction of cassava and new cassava cultivars;
- The farming system, particularly the production of cassava;
- The social structures within each village, particularly any with which we might work.

Several constraints to cassava production mentioned in both Nkaakom and Aworowa were associated with land shortage – notably short or no fallow, having to rent or sharecrop land, and low-yielding varieties. Counter to this, another main constraint was insufficient demand for even the current production of cassava. This fed via low prices into a lack of money to purchase labour (weeding and land preparation especially) and other inputs (herbicides, etc). Clearly, higher yielding varieties could indirectly combat land shortages, allow longer fallow periods, provide a higher return from labour, and provide opportunities to grow other crops. This also led us to consult other stakeholders – both public and private organizations – about alternative markets. This also raised

[1] The project is funded jointly by the Crop Protection Programme and the Plant Sciences Research Programme. It is also part of the international CGIAR Systemwide Program on Integrated Pest Management (www.cgiar.org/spipm/index.htm(anchor1934631) on *Sustainable integrated management of whiteflies as pests and vectors of plant viruses in the tropics: Phase 2 (R8041).*

awareness of the project with key people such as the chair of the National Variety Release Committee. Stakeholders interviewed included the Ghanaian Ministry of Food and Agriculture, the CSIR research institutes, universities and small businesses, while international organisations included a CGIAR institute, foreign government agencies and international NGOs. There was much interest amongst these stakeholders on promoting non-traditional uses of cassava to increase demand for the crop.

Figure 2. **Location of Aworowa and Nkaakom, the two communities in Ghana involved in the participatory cassava breeding.**

Village-based plant breeding

Meetings were held to discuss the field activities at both Nkaakom and Aworowa, shortly after completing the situation analyses. In Aworowa, the meeting was open to all cassava farmers; in Nkaakom, the maize/cassava group provided a focus. The farmers expressed an interest to work with us and land was made available in each village. Seed was obtained from crossing blocks at IITA, Ibadan, Nigeria. The female parents were either highly cassava mosaic-resistant landraces from Ghana, Togo and Nigeria (coded TME (= Tropical *Manihot esculenta*), or TMS (Tropical *Manihot* species) clones with mosaic resistance derived from *M. glaziovii* back-crossed to *M. esculenta* to regain tuber yield.

The seeds of the crosses were direct-planted in June 2000 at Nkaakom and Aworowa, and on-station at Kwadaso (part of CRI) and in Kumasi. The CRI team monitored germination and spare seedlings were used to fill any gaps. Subsequently, pests,

diseases and crop growth were monitored monthly. Men were responsible for initial land clearance, but afterwards, both men and women cultivated the cassava. Cassava mosaic virus disease was the main pest, affecting more than 50% of plants in most families. Farmers evaluated the trials in December 2000 and May 2001. While seldom selecting specifically against mosaic-affected plants, many did select for healthy green leaves (Table 1). Farmers also used indirect measures of yield potential such as stem girth and soil cracking around the plants, caused by the expansion of the tubers underground.

Harvest and the selection of genotypes for further planting were done in July 2001, about one year after planting. Nkaakom was harvested first (Fig. 3). Groups of about six farmers were asked to evaluate each plant pre-harvest and to select about 10 plants they would like to keep for another growing season, recording the key characters of each selected plant through a facilitator. The cassava plants were carefully 'pulled up' so as to keep the tubers attached to the stem and lined up in families. Farmer groups then re-evaluated the plants and re-selected/confirmed the plants they would like to keep for another growing season (Table 2). The CRI plant breeder and the CRI plant pathologists made similar separate evaluations and also selected plants to retain. Plant height, height of the first branches and tuber yield were recorded for all selected plants.

Figure 3. **Nkaakom farmers at harvest, evaluating the cassava plants derived from seedlings.**

Doing both pre- and post-harvest evaluations was time-consuming and repetitive, so only post-harvest evaluations were done at Aworowa and Kwadaso. The seedlings exhibited great diversity, particularly in vigour, branching, susceptibility to cassava mosaic disease, leaf and stem colour and, of most excitement to farmers, in yield, number, size, shape and colour of their tuberous roots. Despite the plants having been derived from seeds rather than large cuttings and the crop having been harvested after only one year, the tuberous root yield per area of many of the seedlings was several times that of the average yield of about 12 t ha^{-1} of cassava in Ghana (FAO data for

2001). Indeed, several farmers asked if the point of the trial was to show them the benefits of planting seeds (we are assuming that the next cycle of propagation using cuttings will confirm our denial of this).

Table 1. **Pre-harvest attributes reported by farmers in two villages, ranked according to the number of times each was mentioned during evaluation. (M = men; W = women).**

	Nkaakom			Aworowa			Overall
Criteria	**M**	**W**	**Rank**	**M**	**W**	**Rank**	**rank**
Stem diameter	57	51	1	76	24	1	**1**
Branching	64	37	1	59	18	2	**2**
Canopy formation	72	38	1	42	13	3	**2**
Healthy/green leaves	34	21	4	35	10	4	**4**
Soil cracking	5	3	5	28	11	4	**5**
Suitability for intercropping	2	16	5	7	3	6	**6**
Resistance to lodging	4	1	5	9	1	6	**6**

Table 2. **Harvest-time attributes reported by farmers in three villages in their selection of plants at harvest.**

	Times mentioned (%)			
Criteria	**Nkaakom**	**Aworowa**	**Kwadaso**	**Mean**
Tuber yield	100	100	100	100
Branching	33	42	17	29
Big stem	33	44	13	28
Tuber shape	5	36	5	14
Weed suppression	18	14	1	10
Healthy leaves	7	16	1	7
Suitability for intercropping	14	0	2	5
Marketable size	2	0	8	4
Neck length of tubers	5	4	0	3
Tuber skin colour	3	0	4	2
Resistance to lodging	2	4	1	2
Early maturity	5	0	1	2
Non-rotten tubers	0	0	4	2
Drought tolerance	1	0	0	0
Disease resistance	1	0	0	0

At each site, the farmers selected 10–15% of the total seedling population, a similar proportion of seedlings to the plant breeder with about 60% overlap with his selections. Cuttings have been obtained from all the plants selected by the farmers, plant breeder and plant pathologists. These have been replanted at each site, each genotype now being represented by a single plot of 12 cuttings (3 x 4). Plots have also been planted with cuttings of local cultivars, nationally released varieties and selections of superior Ghanaian landraces. So far, plants are growing well at each site and about half of the plots of seedling genotypes are free of any cassava mosaic symptoms.

CONCLUSIONS

Major conclusions to date are:

- The work has benefited enormously from the very obvious diversity and overall pest resistance and vigour of the seedling families used.
- The multidisciplinary team approach has been invaluable.
- Farmers appear to have coped well with evaluating large numbers of seedlings.
- The initial situation analyses and stakeholder survey greatly facilitated the collaboration of the project team with farmers and other stakeholders.

Future plans include:

- A survey of cassava breeding by farmers in representative villages throughout Ghana.
- At the next harvest, when there is more material, attention will be paid to the post-harvest qualities of the cassava tubers both as perceived by farmers and by food scientists.

At the moment, the project provides cassava seed to the farmers. It would also be exciting in a next phase of the project to involve the farmers in parental as well as seedling selection.

Testing drought-tolerant plant types of upland rice in Ghana using participatory methods

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BACKGROUND

Rice is becoming an increasingly important staple food consumed throughout Ghana and West Africa, and the per capita consumption of rice in Ghana has more than doubled in the last seven years. Much of this increase in demand is satisfied by imports and the release of improved cultivars to increase domestic production is a national priority. Rice is grown on about 130 000 ha in Ghana, of which more than half is in the upland/ hydromorphic ecosystem. Upland rice is grown in the forest zones in the south (Fig. 1) and the savanna zones in the north of the country (Fig. 2). The major constraints are weeds (Fig. 2) and drought. Average yields are low, less than 1 t ha^{-1}.

Figure 1. **Upland rice field near Todzi, Volta Region, Ghana.**

Figure2. **Upland rice cultivars being evaluated under intensive weed pressure at Nyankpala, Northern Region, Ghana.**

Since 1957, only 16 varieties, all for lowland cultivation, have been released in Ghana; none specifically adapted to uplands have been released to date. However, a

large number of upland varieties are available throughout the region. Furthermore, WARDA have recently developed interspecific crosses between *Oryza sativa* (Asian rice) and *O. glaberrima* (African rice) combining, in many different morphological and physiological types, the hardiness of African rice with the higher yield potential of Asian rice.

The PVS programme in Ghana was initiated in 1997 and has so far been implemented in six out of the 10 Regions of Ghana involving more than 2500 farmers. Researcher-managed, extension/NGO-facilitated and community-managed PVS's and Mother & Baby systems have been piloted with farmers.

RESULTS

Participatory research was conducted in three agro ecological zones in Ghana: in the forest zone at Hohoe, which has a weakly bimodal rainfall pattern and an annual rainfall of 1600 mm; in the transition zone at Aframso, which has a bimodal rainfall pattern with a high probability of drought during the growing season; and in the savanna zone at Nyankpala (Fig. 2), which has a monomodal rainfall pattern and an annual rainfall of 1140 mm.

Meetings were organised at the start of the project with local extension officers, village heads and farming communities in each zone to discuss the proposed programme (Fig. 3). At each location, 30 men and 30 women farmers were registered and semi-structured interviews, mapping, scoring and other exercises were carried out with groups and individuals to describe local rice farming practices, including cultivar selection criteria, and the socio-economic status of the participants.

Figure 3. **Meetings were organised with the village farming community at the start of the project to explain the PVS process.**

Farmers selection criteria and seed management

At all locations farmers grow mostly local *O. glaberrima* cultivars. Farmers have experimented with improved cultivars, usually brought by extension officers, but these are not widely grown. Farmers use a number of characters to assess new genotypes (Table 1), the most important of which are drought tolerance, disease resistance and yield. For example, at Aframso 'Mr More', which as its name implies is a high yielding, improved variety, is deemed better than the local variety with fertilizer and good rains (Table 1). However, for most other traits, and particularly drought tolerance, weed competition and taste, local cvs are preferred.

Table 1. **Comparison of traits of three upland rice varieties at Aframso, Ghana. Farmers scored each variety for traits using between 1 (poor) and 10 (good) pebbles.**

	Score		
Traits	**Mr More**	**Local Red**	**Local White**
Drought tolerance	2	6	7
Disease resistance	4	4	4
Yield with fertiliser	7	4	4
Yield without fertiliser	3	3	3
Yield with 'plenty of rain'	6	4	4
Taste	2	6	5
Market price	4	6	5
Resistance to bird damage	6	1	6
Resistance to stem borer	2	4	6
Competitive ability against weeds	3	6	6

Farmers generally rely on seed saved from the previous crop though occasionally seed may be purchased from a neighbour. At Aframso, great care is taken in selecting and storing seed; panicles are harvested, usually from ratooned plants which mature in the dry season, and selected (in order of priority) on freedom from disease, well-filled grains and long grains. These panicles are then threshed and stored on special platforms in their rooms. Seeds are checked regularly for mould and sorted prior to sowing. In contrast, at Hohoe farmers harvest all seeds at the same time and do not treat seeds for sowing differently from grain for consumption; grains/seeds are stored together in large earthenware pots and any seed left at sowing time is used as seed.

PVS trials

Participatory varietal selection (PVS) trials were established at Hohoe, Aframso and Nyankpala with between 60 and 100 entries. At Hohoe and Aframso these entries included lowland, hydromorphic and upland varieties and breeding lines, while at Nyankpala entries were mostly hydromorphic and upland varieties and breeding lines. The PVS trials were arranged in two blocks, low and high input, differing in weed pressure and fertility, with repeated checks. Men and women farmers were invited to evaluate and select varieties four times: during the vegetative and flowering stages, and at harvest and post-harvest.

Mean yields in 1998 in the PVS trials were 1.85 t ha^{-1} at Nyankpala, 1.52 t ha^{-1} at Hohoe and 0.67 t ha^{-1} Aframso. Aframso had the lowest yields because of drought. The maximum yield recorded at Hohoe and Nyankpala was nearly 4 t ha^{-1}.

Farmers used a wide range of criteria to evaluate new varieties, depending on the stage of crop growth (Table 2). During vegetative growth, farmers selected for traits that contributed to greater weed competitiveness, e.g., broad leaves, plenty of tillers and vigorous early growth, while at the post-flowering stage it was plant height and panicle traits that farmers equated with yield. Unsurprisingly, therefore, choices varied with the stage of crop growth (Fig. 4). For example, at the vegetative stage at Nyankpala varieties with good weed competitiveness were selected: e.g., local *O. glaberrima* cvs such as Kpukpula and high tillering *O. sativa* indicas. Interestingly, at Nyankpala, WAB 36-54 and WAB 224-8-HB (both improved japonicas), were selected at all three stages of development. These were selected because of their tall height, tillering ability, weed suppression ability, large panicles and large grains.

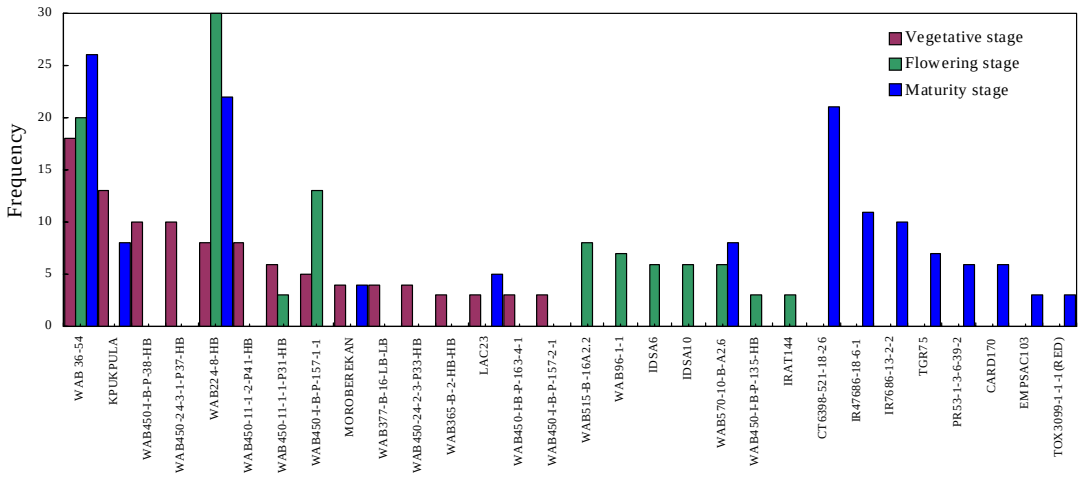

Figure 4. **Frequency of selection of varieties by 60 farmers at three stages of crop growth at Nyankpala, Ghana in 1998.**

At Nyankpala, farmers made selections independently in the low and high input blocks, and the frequency of selections at harvest are shown in Fig. 5. Of the 14 most frequently selected varieties in low or high input blocks, 11 were selected in both blocks, many with similar frequencies. This is encouraging, since it suggests that the traits of interest to farmers are expressed in different agronomic conditions and that a number of varieties are adapted to both high and low input conditions. CT6398-521-18-2B did particularly well in both low and high input conditions, WAB36-54 under low input conditions, and Kpukpula (a local cultivar) and CARD 170 under high input conditions.

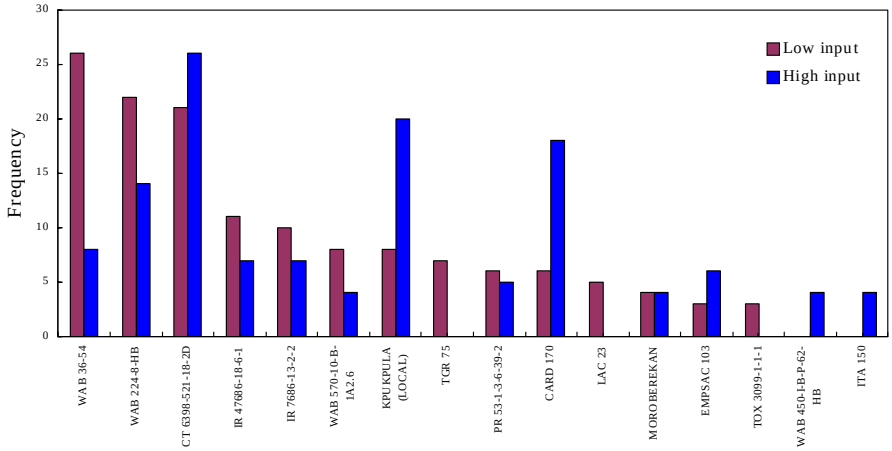

Figure 5. **Frequency of selection of cvs in low-and high-input conditions at maturity by 60 farmers at Nyankpala, Ghana in 1998.**

At Aframso and Hohoe, male and female farmers made independent selections at all four stages of development. At both locations, and at each stage of development, male and female farmers generally made similar choices (Fig. 6). The only notable difference between male and female selections was that females always included some local varieties with red grain colour among their selections, as these are used in the preparation of traditional dishes for festivals.

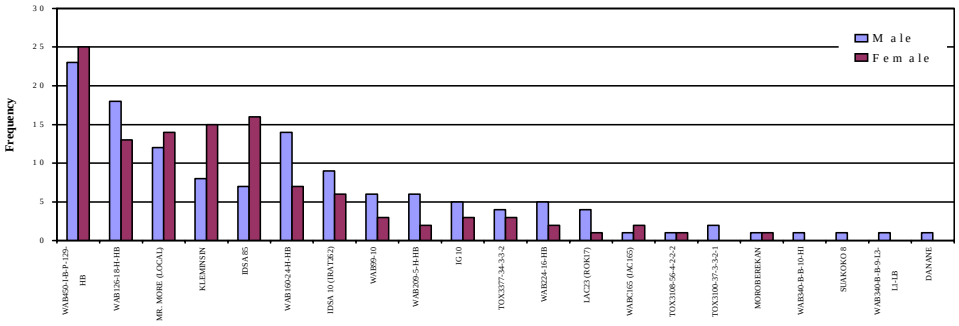

Figure 6. **Frequency of selection of varieties by 30 male and 30 female farmers at maturity at Aframso, Ghana in 1998.**

At Aframso (Fig. 6) and Nyankpala (Fig. 5) a wide range of varieties were selected at harvest, and these included local *glaberrimas*, improved upland *japonicas* (e.g., WAB 126-18-H-HB, WAB 36-56) and interspecific progenies (e.g., WAB 450-I-B-P-129-HB). However, at Hohoe (Fig. 8), IDSA 85, was selected by the majority of farmers because of its highly desirable grain characteristics. One or two varieties were

selected at more than one location (e.g., IDSA 85, WAB 126-18-H-HB, Moroberekan and LAC 23), but as expected choices were different in the different agroecological zones.

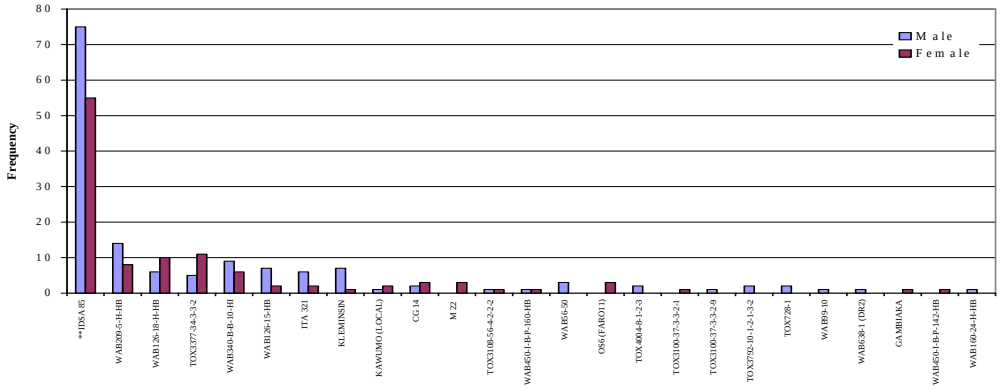

Figure 7. **Frequency of selection of varieties by 30 male and 30 female farmers at maturity at Hohoe, Ghana in 1998.**

Post-harvest evaluations

Taste and other organo-leptic traits are extremely important selection criteria and better taste and higher market price are key reasons why local varieties of rice are preferred (Table 1). Between 10 and 18 varieties were milled and evaluated by male and female traders at two major markets at Tema (Accra) and Kumasi. Market traders value long, bold, white grains as these are closest to those of imported rice. IDSA 85, Kleminson and WAB 126-15-HB all scored highly for these traits with traders. Genotypes with coloured grains were also selected as these command a price premium for local dishes.

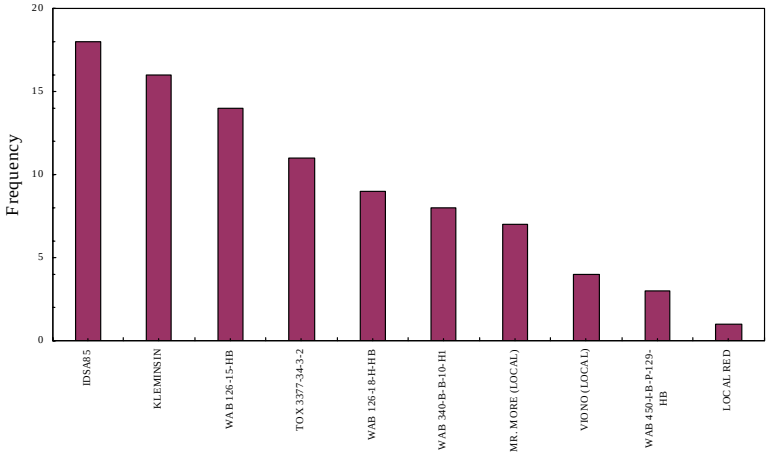

Figure 8. **Frequency of selection of varieties by male and female market traders at Tema**

and Kumasi, Ghana 1998.

Male and female farmers and consumers also evaluated cultivars for the sensory traits (Table 2). Expansion ability is particularly important in the drier and northern areas where rice is par-boiled. Thus, while consumers at Hohoe were satisfied with the expansion ability of all the varieties tested, consumers at Aframso were far more discriminating. IDSA 85, WAB 126-18-H-HB and Kleminson all scored highly for this trait, confirming the higher market value traders gave them (Fig. 8). However, local varieties always had higher scores, particularly when scored by females, than improved ones for aroma and taste, and the overall ranking of improved varieties such as IDSA 85 was poorer than the local varieties (e.g., Local Red at Aframso: Fig. 9). Nonetheless, most farmers express an interest in IDSA 85 because of its higher market value, particularly at Hohoe.

Table 2. **Selection criteria used by male and female farmers to evaluate rice varieties in Ghana**

Stage	Criteria		
During crop growth	Yield	Lodging	Leaf Serration
	Plant Height	Plant vigour	Panicle excision
	Tillering ability	Plant Architecture	Leafiness
	Leaf shape/width	Plant appeal	Uniformity of maturity
	Panicle Size	Canopy density	
	Maturity Period	Tiller length	
At harvest	Grain length	Boldness	Grain hardness
	Grain taste (milk)	Grain colour	Market value
	Grain size	Milling recovery	
Sensory Traints	Aroma	Taste	Hardness
	Expansion ability	Stickiness	

Informal Seed Dissemination and Uptake Pathways

In 2000, seed of eight upland rice varieties was distributed to farmers (1-2 kg per farmer) using different pathways in five communities around Hohoe. The most successful dissemination method was a community seed bank, whereby for each kg a farmer received, 2 kg had to be returned to the bank after harvest. Two communities independently organised such a seed bank. Irrespective of how seed was initially distributed, seed moved first through kin relations, often by exchange, and was only sold when larger quantities were available. Seed sold at a premium and demand far outstripped supply in the first two years. However, by the third year a few seed producers were harvesting large quantities of seed and there was a noticeable increase in uptake. By 2000, seed given to six villages had spread to 40 km by 2001 (Fig. 10). By 2003 seed had moved >100 km through informal channels.

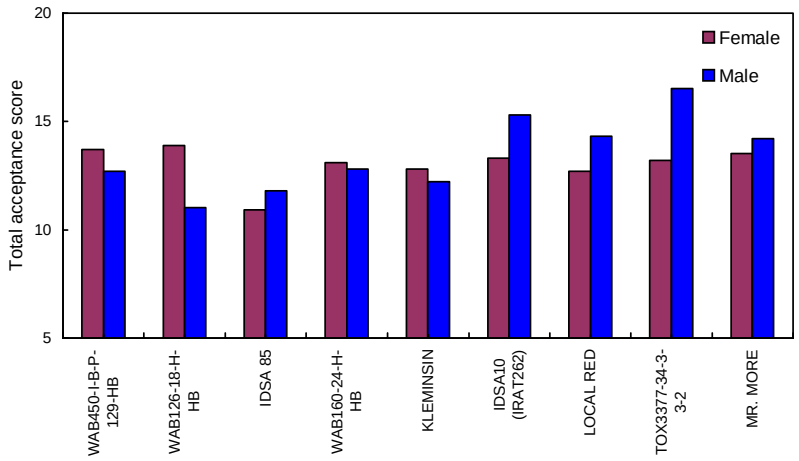

Figure 9. **Overall acceptance scores (maximum 20) for varieties evaluated for their cooking quality by male and female farmers and consumers at Aframso in Ghana in 1998.**

Farmer adoption of new PVS varieties

A survey of approximately 2500 upland farmers around Hohoe was undertaken five years after the project began and showed that that 36% of households were growing a PVS cv, and 83% were aware of PVS cvs. The most popular cv was IDSA85, a cv with a highly desirable grain type, and which farmers named '*Idana*', meaning you'll not be tired to reflect it's ease of threshing. Three other cvs from the original PVS (WAB209, WAB126 and WAB340) were also being grown widely.

In northern Ghana, SARI formally released a cv, IR12979-24-1 using a combination of formal and PVS/ Mother & Baby data. This cv was first tested in 1985 but was promoted only after it's inclusion in a PVS in 2000 and subsequent selection by many farmers. This cv performed outstandingly well on-farm. An integrated system of PVS/Mother & Baby trials and formal multi-locational testing is proposed to release cvs in Ghana.

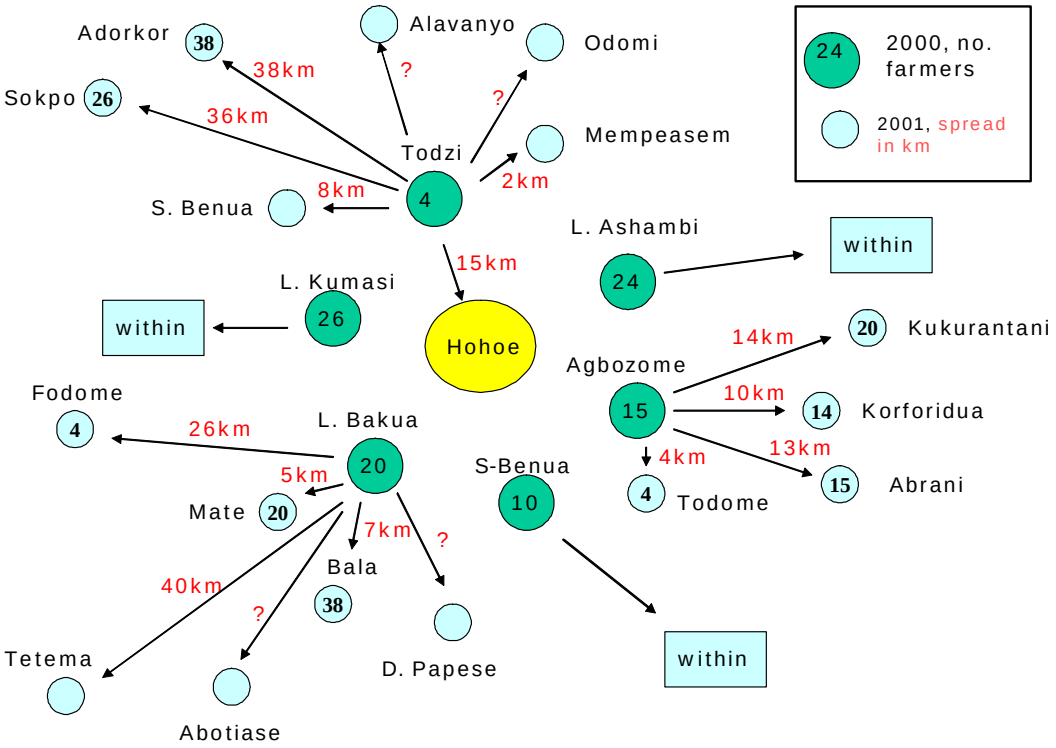

***Figure 10*. Seed dissemination in Volta Region in 2000 and spread in 2001.**

Delivering impacts from participatory crop improvement projects in Nepal

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ABSTRACT

Participatory crop improvement (PCI) for new varieties and crops started in 1997 in Chitwan and Nawalparasi. Subsequently the results were disseminated (scaled up) in many districts in Nepal. LI-BIRD (an NGO) implemented the project jointly with the Centre for Arid Zone Studies.

Initially the mode of collaboration with the Department of Agriculture (DoA), particularly with its district officers and Nepal Agricultural Research Council (NARC), was consultative. They were not active partners but there was an exchange of ideas and experiences. Collaborative participation, where partners played an active role, started first with District Agricultural Development Office (DADO) Chitwan who actively disseminated project identified rice varieties using the project's participatory approaches. Later other DADO offices became actively involved as well as the National Rice Research Programme (NRRP).

INTRODUCTION

In last year's annual report we presented the results of an impact assessment of the Programme's projects on participatory crop improvement (PCI) in Nepal. These projects involved participatory technology development in agronomy, new varieties and crops, and multipurpose trees. The impact assessment concentrated on the delivery of benefits to farmers. Here we describe the institutional innovations that have resulted from project outputs.

IMPACT IN NEPAL

Background

The total area of rice in the Terai is about 1.1 to 1.2 million ha, i.e. ca. 75% of the total rice area of Nepal. It is estimated that about 70% of the main-season rice in the Terai is grown under rainfed and limited irrigation water conditions.

Participatory surveys revealed that many of the farmers in the project villages of Chitwan and Nawalparasi, were growing old varieties of rice, e.g. *CH 45* (44 years) and *Masuli* (28 years) or varieties that have not been recommended such as *Ekhattar*, *Kanchhi Masuli*, *Radha 17* and a large number of landraces. The PCI projects have identified an increasing number of rice varieties, using both participatory varietal selection (PVS) and participatory plant breeding (PPB) approaches. Fifteen varieties have been identified that are suited to poorer farmers who cultivate the less productive medium upland and upland conditions. These varieties give increased profits to farmers and where they were first tested (Chitwan and Nawalparasi districts) rates of adoption exceeded 40% of the rice area in many of the 34 villages surveyed in 2002.

Evidence of Institutionalisation of PCI Projects Outputs

Letters of Agreement

1. *Letter of agreement (LoA) between DADO Chitwan and LI-BIRD*: A new feature of this partnership was that a LoA (Box 1) was signed between the district level authority of the government line agency, DADO Chitwan, and with the NGO, LI-BIRD. This may be the first example of its kind. This collaboration is also noteworthy in that it was instigated by DADO Chitwan rather than LI-BIRD.

2. *Letter of agreement (LoA) between LI-BIRD and Farmer Groups:* Another important partnership that is emerging is between NGO-Farmers Groups or community-based organisations (CBOs). LI-BIRD has signed three separate LoAs with three CBOs in Nawalparasi (for example Box 2), one of which was formed by DADO office while the other two were self-organised.

Box 1: ***Letter of Agreement between DADO Chitwan and LI-BIRD for participatory scaling up.***

Roles of DADO

- Fully responsible for the implementation of scaling up activities through their networks.
- Prepare joint annual plan and get approval of the Ministry through regular planning process.
- Periodical monitoring.
- Collect field information and prepare progress and technical reports.
- Provide financial and other institutional support to new, unreleased varieties in exactly the same way as if they had been released.
- Farmer and staff skill development on participatory approaches through orientation, training and exposure visits.
- Organise periodical coordination and review meetings with LI-BIRD.

Box 2: ***Scaling up through Farmers Groups (FGs) in Nawalparasi.***

The process:

- PRAs to identify community-based organisations (CBOs) suitable for participatory scaling up.
- Documentation of profile of short-listed CBOs by PRA.
- Selection of established FGs.
- LoA with three FGs – two mixed groups and one women farmers group.
- Implementation of programme through FGs.

Roles of FGs:

- Responsible for carrying out all the field activities: farmer identification (focus on poor and medium farmers), distribution of seeds, record keeping including the monitoring of varietal uptake.
- Seed production and farmer-to-farmer distribution.
- Decision making.

Roles of LI-BIRD:

- Identify FGs and provide seeds of new farmer-preferred varieties.

The Spread of Institutional Innovations to Other District Offices and Organisations

The extent of the innovations differ greatly between organisations and District Offices, but have been taken up in 20 Terai and 9 hill districts. In these initiatives, LI-BIRD, in addition to working closely with DoA, is also collaborating with other NGOs, e.g. FORWARD, CARE and PLAN International.

1. A stakeholders meeting was organised in Kathmandu in February 2001 to discuss the possibility of participatory scaling up of the research outputs through GO-NGO partnerships. The meeting agreed on the advantages of participatory scaling up and a joint Working Group of DoA, NARC and LI-BIRD was established. A similar Working Group was formed to look into the policy issues related to the release of varieties identified by PVS or bred by PPB. The first Working Group developed a proposal to scale up the activities in four districts, Dhanusha, Sarlahi, Bardiya and Kailali, which was finally approved by the authorities from DoA, NARC and LI-BIRD at a subsequent workshop. The World Bank funded project 'Agricultural Research and Extension' (AREP) agreed to provide a grant for this work. Farmer-preferred rice varieties were scaled up in 2001 in each of four districts and were evaluated by farmers in major rice growing domains.

2. A workshop was jointly organised in January 2002 by DoA and LI-BIRD to share the findings from the five collaborating district offices. Representatives from seven DADOs also participated and developed seven project concept notes for scaling up PVS-identified and PPB-produced varieties. The possibility of incorporating the plan into the regular planning process of DoA to attract funding was discussed. Some of the DADOs have already incorporated this into their regular plan, indicating greater acceptance and uptake of the approach by the DoA.

3. A workshop was organised in December 2002 to review the progress made during the 2002 rice season and also plan for 2003. Representatives from 19 DADOs participated in the programme along with several NGOs and INGOs.

Spillover of Institutional Innovations from Nepal to Bangladesh

1. DFID-PSP organised a meeting in February 2001 at the Bangladesh Rice Research Institute (BRRI) with the objective of exploring the possibility of sharing rice technologies and experiences between Bangladesh and Nepal. Following this meeting *boro* rice germplasms from Bangladesh and farmer-preferred rice varieties identified from PVS and PPB approaches from Nepal have been exchanged.

2. An NGO, PROVA, evaluated seven rice varieties in 2002 from Nepal, in the High Barind Tract (HBT) of Bangladesh and they showed very good promise. In 2003, 19 short duration rice lines, mainly the products of PPB, have been sent to BRRI for evaluation at their Rajshahi Regional Station. This will generate additional data particularly on disease resistances so that promising, short-duration lines can be integrated into their system. Some of those lines have also been sent to PROVA for testing in mother-baby trials, and for dissemination by informal methods.

3. Capacity building on participatory research and scaling up for farmers, support staff, researchers and development professionals has been a regular activity throughout the project. Very recently an orientation workshop for GO and NGO professionals from Bangladesh and Nepal was also organised. These are proving to be very fruitful exercises in terms of developing critical mass for participatory research and scaling up.

Impact of Participatory Research and Scaling up on Rural Livelihoods: Case Studies on Swarna rice.

1. ***Parwati and Arjun Kumar Shrestha*** of Agauli VDC (village Development Committee) Ward 5, Sherganj, Nawalparasi explained that they only own 6 *Kattha*[1] (about one fifth of a hectare) of low lying *Khet*[2] land where Masuli was grown before adopting Swarna. Masuli never produced more than 15 *Moori*[3] from the land which was just enough to sustain their six member family for about six months. They heard about Swarna three years ago and tried a small plot in the first year. Parwati says that the variety to her surprise did extremely well even under submerged conditions, where Masuli generally does very poorly. Impressed with the performance of Swarna this couple decided to plant the entire plot to the new variety. The yield from the new variety was nearly double that of Masuli, i.e. 27 *Moori*. This couple comes into the food deficit category, but this year sold nearly 500 kg Swarna and bought corrugated iron sheets for a cow shed. This was possible as they also grew *Chaite* rice and the entire harvest from *Chaite* rice was kept for home consumption. They also distributed nearly 75 kg seeds of Swarna. They are keen to continue with this variety as they see the clear advantage from this in meeting the food security of their family. While discussing with the Shrestha couple it was learnt that Swarna is becoming popular among the farmers and it has contributed to meet the food needs of about 50% of farmers (like this family) in Sherganj village (the percentage of smallholder farmers in that village is quite high).

[1] *Kattha* is a local unit used for measuring land area, one *Kattha* is equivalent to 338 m^2.
[2] *Khet* is bunded and irrigated land where transplanted rice is grown.
[3] *Moori* is a local unit used for measuring volume. One *Moori* of rough rice is equal to 50 kg.

2. ***Sarswati and Sita Thanet*:** These two women live in a joint family of 15 members at Bamnauli, Abhiyun. They belong to the food surplus category with a land holding of over 2 ha. Sources of income for the family are: sale of rice, sale of vegetables, income from rice mill, tractor and salary from the Nepal Army. They have been growing Swarna for the last five years. Started with a participatory varietal selection trial (PVS) in 1999, Swarna now covers nearly 55% of their *khet* land. In spite of diverse sources of income they considered that rice contributes nearly 75% of all the family requirements. All the day-to-day family expenses including labour and inputs for the farm are met through the income from the sale of rice. Both the ladies told us that the family requirements including cash expenditure has nearly doubled over the last five years as the family is ever increasing and cash expenditure has particularly increased due to schooling of children including their clothing, health care etc. They reckon that yield of Swarna is nearly one and a half times more than Masuli. In the past they sold nearly 4 t of rice while it has increased to 6 t after the adoption of Swarna. The increased income has particularly contributed to the education of children and health care. They mentioned one particular instance where Sarswatis' leg was badly fractured, she was in the hospital for nearly two years and this is where the income from the sale of rice was used.

3. ***Tek Kumari Thanet,*** Sherganj also owns 7 *Kattha* of land. Like most other farmers she also grew Masuli in the past. She has been growing Swarna for the last two years. Food requirements of her four member family have increased now and the harvest from Masuli was not enough even in the past when the food need was less than now. Tek Kumari says that after growing Swarna she does not have to buy rice.

4. ***Dhan Kumari and Om Narayan Mahato:*** This couple belongs to a food balance category. They live in Agauli. Apart from Swarna, this family has been growing a number of new rice varieties introduced by LI-BIRD in their PVS programme, for example, Pant Dhan 10, Barkhe 1027 and BG 1442. Before these new varieties they were growing Sabitri, a variety released by the National Seed Board. They abandoned this variety, as it is highly susceptible to zinc deficiency, is difficult to thresh, is also prone to high leaf folder damage and also yields less than Swarna. They have been growing Swarna for last four years, one year while they were still in a joint family and three years after they got separated from the joint family. They clearly see that Swarna is higher yielding than Sabitri. They also have other sources of income, e.g. vegetables and banana. However, net income from Swarna this year was at least Rs. 10,000. This family used the income from the sale of Swarna over the last three years for several things; e.g. they paid about Rs. 9000 loan that was accumulated from the joint family. This year they spent nearly Rs. 11, 000 to put corrugated iron roofing in their house. They also invested some money while establishing their small banana orchard. They say that their family needs, including cash requirement, has increased due to schooling of the children and for vegetable and banana farming but now they do not see any problem to meet it. "With Sabitri, I was just meeting my family needs but it would have not been possible with out Swarna to repay the loan, go for improved roofing or pay the school fees of my children"