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Highly Client-Oriented Breeding: The Impact of Two Upland Rice Varieties in Eastern India

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HIGHLY CLIENT-ORIENTED BREEDING: THE IMPACT OF TWO UPLAND RICE VARIETIES IN EASTERN INDIA

By **DS Virk[1], VA Bourai[2], A Choudhary[3], M Misra[4], A. Mottram[1] and JR Witcombe[1]**

[1]CAZS Natural Resources, University of Wales, Bangor, Gwynedd, UK. [2]Department of Economics, Sri Guru Ram Rai College, Dehradun (Uttranchal), India. [3]Gramin Vikas Trust, Pani Jahaj Kothi, Kanke Road, Ranchi, India. [4]Department of Economics, Sri Guru Ram Rai College, Dehradun (Uttranchal), India.

ABSTRACT

As the result of a highly client-oriented breeding programme in eastern India, two rice varieties (Ashoka 200F and Ashoka 228) were officially recommended for the upland rainfed farming systems in Jharkhand. Surveys were undertaken in 2002 and 2004 to determine their impact, over 2002, 2003 and 2004, on the livelihoods of farmers in eastern India.

Farmer preference for the new varieties was high. 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. Most farmers also perceived the new varieties to be earlier, higher yielding, and more resistant to drought and lodging. In the 2004 survey, farmers reported that in 2002 and 2003 their grain fetched a higher price in the market (an average premium of 12%).

The new varieties significantly improved household income, with most farming households reporting that the effect on income was large. In the 2004 survey, over 60% of farmers reported increases in on-farm income of at least 20%.

Farmers adopt the varieties on a high proportion of their uplands, and in villages that had only recent access to seed overall adoption was around 26% of the upland rice area.

Seed multiplication is being undertaken by 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. In 2004, Ashoka 200F was officially recommended for cultivation in Rajasthan state.

A financial analysis, using conservative assumptions showed that the cumulative benefits from this project will be greater than the total expenditure on the Plant Sciences Research Programme for the period 1995 to 2005.

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 susceptible to diseases and pests. More efficient plant breeding that is highly client oriented (Witcombe *et al.*, 2005) has provided a rapid, cost effective solution to these problems by developing new upland rice varieties superior to the landraces (Virk et al., 2003).

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 client-oriented breeding (COB) programme. They were bred in a collaborative project, which began in 1997 between the Gramin Vikas Trust (GVT) in Ranchi, Jarkhand, India; BAU; and CAZS Natural Resources, Bangor, UK.

Surveys were undertaken in 2002 and 2004 of adopting farmers to estimate the impact of these varieties.

BACKGROUND

Farmers of rainfed uplands require early varieties that escape end-of-season drought but still give a good yield of grain and fodder. GVT gave farmers a choice of upland varieties for farmers to test for themselves in their own fields. This process is called participatory varietal selection (PVS) and farmers identified Kalinga III as the best of the modern varieties. It has early maturity, high grain and fodder yield and good cooking quality but farmers did not adopt it in large numbers or areas because of its poor inherent resistance to drought. Kalinga III was crossed to another rice variety, IR64, to improve it in a breeding programme targeted at improving the traits that farmers wanted in a new variety. This client-oriented breeding programme produced two outstanding rice varieties (Ashoka 200F and Ashoka 228).

We report here on a study that assessed the outcomes from producing and popularising these new varieties.

MATERIALS AND METHODS

We describe here the results of surveys, in 2002 and 2004, of farmers who had access to seed of the Ashoka varieties. Data were collected for 2002, 2003 and 2004.

The impact was studied in villages where seed had been distributed either directly or indirectly by GVT. In December 2002, about 15% of the households were randomly sampled from the 1000 that received seed from the GVT (Bourai *et al*., 2002). There were 126 sample households[†] from the GVT villages and farmers from these households were interviewed using a semi-structured format. In March 2004, several hundred households were surveyed (Virk *et al*., 2004). In addition, a further survey in October 2004, was conducted that, instead of household interviews, used maps and group discussions (Mottram, 2005).

SEED TRANSACTIONS

2002 survey. Farmers sold seed to farmers within the villages but also outside the villages up to a distance of 300 km (Table 1). The quantities sold in Orissa were large because the project facilitated seed sales and the survey included farmers who were members of GVT-organised seed producer groups. Other than this, the spread of seed was through relatives and friends. The seed was distributed over long distances. For example, from Haldikundi village, Orissa, the seed spread as far as 60 km.

2004 survey. In the 2004 survey, on average, 40% of the farmers distributed seed from the 2002 and 2003 harvests. The average amount of seed sold, gifted or exchanged per transaction was over 20 kg in both years.

The distribution from the 2003 harvest is likely to be an underestimate because the survey took place in January before the period of greatest demand for seed. Other factors could lead to an underestimate of farmer-to-farmer seed supply. The farmers who were surveyed all had good contact with the GVT project and had less incentive to distribute seed than 'non-project' farmers. Seed distribution is a means of securing a future seed supply and farmers with a close contact with the project can always ask it for more seed. Non-project farmers have much more reason to supply seed to other farmers as it provides a future seed source.

[†] 56 in Jharkhand, 29 in Orissa, and 41 in W. Bengal. Included 23 households from those who got seed through NGOs, and 10 from those who received seed through the state department of agriculture

FARMERS' PERCEPTIONS OF THE NEW VARIETIES

In the surveys in 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 (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 12% (Rs 6.5 kg^{-1} for the Ashoka varieties compared to Rs 5.8 kg^{-1} for the local variety). In Jharkhand and Orissa the price advantage was higher (16%), the lower average resulting from a 6% advantage in West Bengal where the surveyed farmers commonly grew the higher value Kalinga III.

Most farmers report that the new varieties have better drought tolerance. They performed extremely 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.

ADOPTION

An increasing trend in the area of cultivation of the two varieties was found in the 2004 survey (Fig. 1). The higher values obtained in the smaller, earlier survey in 2002 are not shown.

The adoption rates in Fig. 1 gives an indication of how much land adopting farmers will devote to the new varieties but does not give an estimate of the coverage overall. In 2004, a mapping exercise was done in eleven villages where every upland field was identified and the variety grown determined from discussions with groups of local farmers. The rate of adoption of the Ashoka varieties has been high and within 2 years of their introduction to a village they are being cultivated on about 26% of the upland rice area (Fig. 2). The area of Ashoka cultivation is increasing every year and its cultivation has enabled some farmers to increase their total area of cultivation by utilising fallow upland areas.

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	
	kg	km	kg	km	kg	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	

***Table 2*.** Farmers' perception (expressed as % of farmers) for Ashoka 228 and Ashoka 200F r in March 2004.

Trait	2002[1]			2004[1]		
	Ashoka preferred	Local preferred	Same	Ashoka preferred	Local preferred	Same
Grain yield	92	2	5	97	0	3
Straw yield	68	5	25	76	0	24
Maturity	87	4	6	96	2	2
Drought tolerance	82	1	14	46 [2]	0	0
Weed suppression	69	1	28	- [3]	-	-
Market price	89	0	10	80	0	20
Eating quality	82	2	12	80	0	20
Overall preference	91	1	6	-	-	-
Grow Ashoka variety again?	97	3	0	100	0	0

[1] The total may not be 100 as 'no response' class has been omitted.
[2] Perception based on only 74 farmers who reported it as additional property of Ashoka varieties.
[3] Not recorded in 2004.

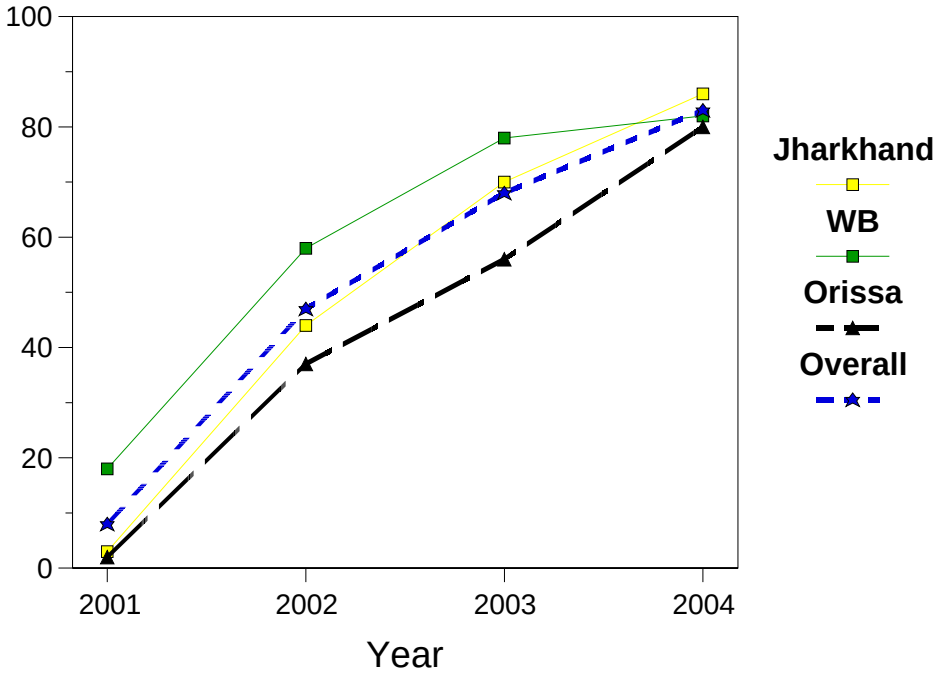

Figure 1. Increase in cultivated area of the new rice varieties from 2001 to 2002 by adopting farmers and the projected proportion of the area for 2004. Based on a survey of 150 farmers in 2004.

Ashoka varieties were being adopted at such high rates because they have several benefits over local varieties including high yield, early maturity (90 days), drought resistance, good taste and short cooking time, good straw quality and high market price compared to local varieties (4-4.5 Rs/kg compared to 3.5-3.8 Rs/kg). The benefits of Ashoka over many local varieties means that it is replacing poor quality local varieties, but diversity is being maintained through preservation of varieties with different qualities to Ashoka and those that are still maintained for traditional cultural practices.

Adoption will be more widespread because of the acceptance of these varieties elsewhere in the country. The GVT Western India Rainfed Farming Project, in collaboration with State Agricultural Universities, 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. In 2004, Ashoka 200F

was recommended for cultivation in Rajasthan by the Maharana Pratap University of Agriculture and Technology (MPUAT). In the three states of the western project GVT already has an active seed multiplication and distribution programme for these varieties.

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).

Ashoka 200F and Ashoka 228 are high-yielding, early-maturing, drought-resistant varieties, and because they have fine grains they fetch a high marker price. Farmers in eastern GVT reported major benefits for their livelihoods; food is available in years of poor rainfall and during the lean periods of the year, and straw is available for fodder earlier in the season. Additional cash from the sale of surplus grain, or because grain no longer has to be purchased for household needs, was used by the farmers for various purposes such as children's education, food and clothes (Fig. 3). However, the most important impact reported by most farmers was that cultivation of the Ashoka varieties resulted in increased household food security – on average by 1-2 months. In some cases, grain-deficit households were now self sufficient.

SEED PRODUCTION AND SALES

There are over 5 million ha of uplands presently under landraces in eastern India (Muralidharan *et al.*, 1988). 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, 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 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.

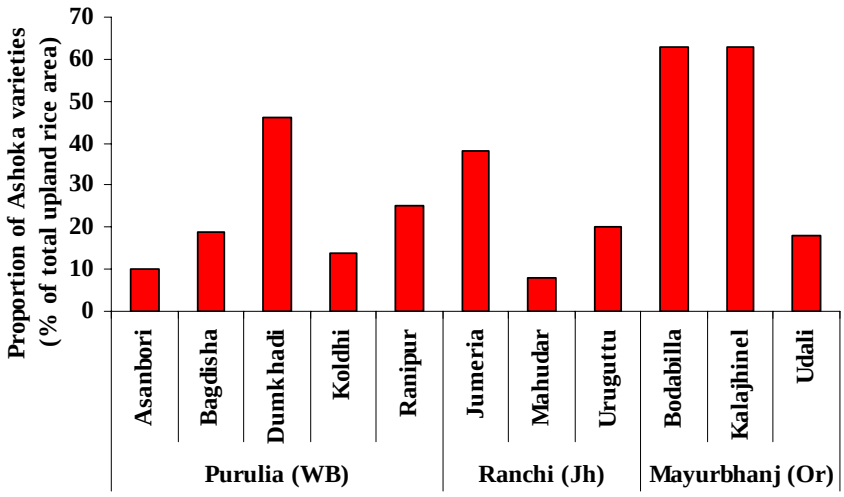

Figure 2. Adoption of Ashoka rice varieties in villages in Purulia ditrict, West Bengal (WB); Ranchi district, Jharkhand (Jh); and Mayurbhanj district, Orissa (Or).

Table 3. Impact of new varieties on overall income based on survey in Dec 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 and market price based on survey in March 2004.

State	N	Rice sold (kg)		Rice lasts (months)		Price (Rs kg^{-1})	
		Before	After	Before	After	Before (local)	After
Jharkhand	57	1	10	6.1	10.3	6.0	6.8
West Bengal	60	45	60	7.9	9.7	6.3	6.6
Orissa	33	70	238	8.7	10.5	4.6	5.4
Overall	150	34	80	7.4	10.1	5.8	-
Increase (%)			137		36		12

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

State	N	<10%	10-20%	20-30%	30-40%	>40%
Jharkhand	57	11	52	32	5	0
West Bengal	60	22	45	17	10	6
Orissa	33	24	36	24	6	9
Overall	150	19	44	24	7	5

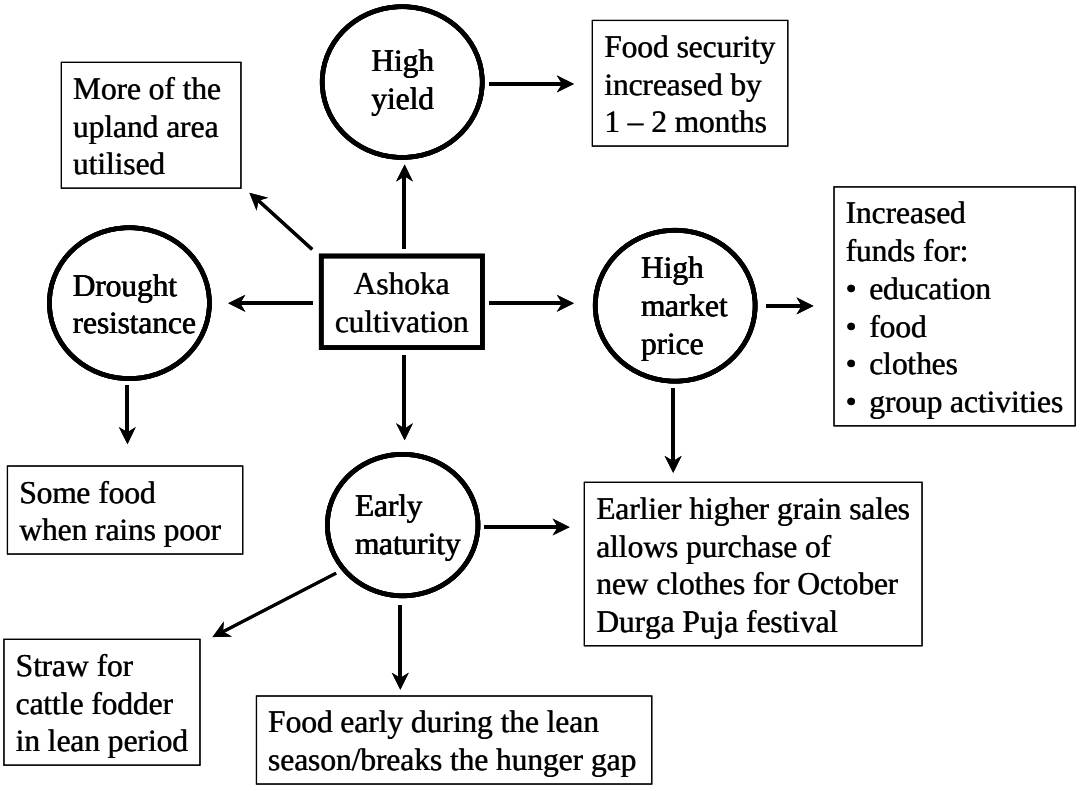

Figure 3. Diagram of the effects cultivating Ashoka can have on farmers' livelihoods, as determined in farmer group discussions. The diagram is a summary of group responses from 14 villages in three districts, Oct 2004.

Table 6. Seed production of Ashoka 228 and Ashoka 200F facilitated by GVT in eastern India in the dry season of 2001-02, 2002-03, 2003-04, 2004-05.

	2001-02	**2002-03**	**2003-04**	**2004-05**
Total	45	70	82	17

The GVT distributed the seed to its adopted villages in Jharkhand, West Bengal and Orissa in all years apart from providing the seed to other agencies. For the 2002 rainy season GVT distributed seed to the State

Departments of Agriculture, NGOs and private seed growers in the three eastern Indian states and to the GVT's western Indian counterpart.

For the 2003 season GVT 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.

For the 2004 season GVT distributed seed to:

- Catholic Relief Services (CRS) in Jharkhand, Chhattishgarh and Madhya Pradesh;
- State Departments of Agriculture in the three eastern Indian states;
- State Agricultural Universities such as Birsa Agricultural University, Jharkhand, University of Agricultural Sciences, Dharward, Karnataka, Tamil Nadu Agricultural University, Coimbatore;
- DFID funded Orissa Western Livelihood Project;
- NGOs such as Jharkhand Tribal Development Society, Ranchi, SPEED, Dehradun, Utranchal Pradesh, ASA, Bhopal, Madhya Pradesh,
- Private seed companies in Jharkhand.
- In West Bengal the seed was also distributed to 9 NGOs and 6 government organisations.

For the 2005 season GVT distributed seed to:

- Catholic Relief Services (CRS) in Jharkhand, Chhattishgarh and Madhya Pradesh;
- Birsa Agricultural University;
- State Departments of Agriculture in the three eastern Indian states;
- Farmers in new villages adopted by GVT in Jharkhand, West Bengal and Orissa.

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.

The Ashoka varieties are very well accepted 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 rainfall around the middle of August enabled it to recover and produce a bumper crop. In the worst drought hit area of the Kalahandi district in Orissa the Deputy Director of Agriculture reported the outstanding performance of Ashoka 228 when the local varieties had failed. However, even drought-tolerant varieties will decline in poor years as farmers greatly reduce the area under upland rice in response to late rains.

An example financial analysis was made of the benefits that these varieties, in just three states (Jharkhand, Orissa and West Bengal), can bring (Fig. 4). Any predictive model is far too sensitive to be reliable. Instead, we assume a reasonable scenario on the basis of our data and then examine the financial impact that would have. On the basis of a 25% adoption in villages after two years of exposure and an acceptance rate of nearly 100% then adoption of 10% of the upland area in eastern India is a reasonable scenario. With these assumptions the benefits are not over-optimistic. The benefits are large and anticipated cumulative benefits by 2012 would be greater than the total expenditure of £19.5 million on the Plant Sciences Research Programme between 1995 and 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 and BAU as the project implementers. The benefits are sufficiently substantial for credit sharing.

Assumptions

- Reference year of 2002 with a research spend of £0.5 million by that year and a further annual expenditure of £100,000 for research and development
- An adoption of 10% of the upland rice area by 2010 and no increase thereafter.
- An increased benefit per hectare from Ashoka 200F and Ashoka 228 of £33 per hectare (500 kg additional yield at £0.09 kg^{-1}).

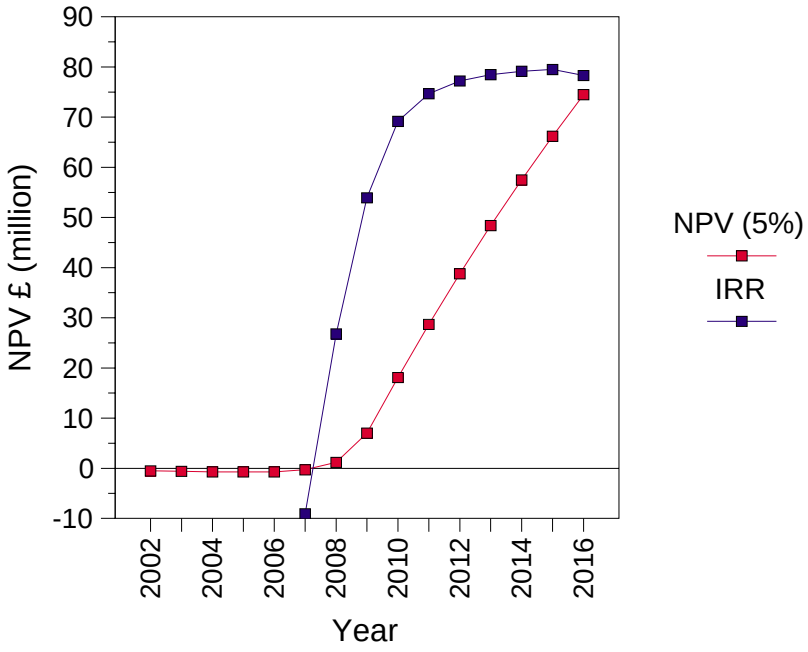

Figure 4. NPV and IRR over time from the new rice varieties using the assumptions described in the box above.

If higher (but still probable) assumptions on adoption 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 a high adoption ceiling will be achieved. The major variable is how quickly that adoption ceiling will be achieved and, hence, how quickly substantial benefits will be realised.

All of our scenarios also ignore the benefits from 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. These scenarios do not consider adoption of varieties from the programme that are adapted to the even more extensive areas of the medium land ecosystem.

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