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Participatory Research

A farmer happy with his new rice variety, Barkhe 2001. It is an outstanding new variety from participatory plant breeding that is being evaluated in a partnership between farmers and governmental and non-governmental organisations.
Participatory Research

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A brief introduction to participatory varietal selection and participatory plant breeding

JR Witcombe

Centre for Arid Zone Studies (CAZS), University of Wales, Bangor, UK

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 should be selected carefully. To save time and ensure availability of seed we have used already-released cultivars, not only from the target region, but from other regions or countries. For example, in India, rice and maize cultivars can be found that have only been released and widely grown in a single state, yet have a potential to be useful in others.

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 in upland rice in Ghana (Dogbe and Craufurd, 2002) resulted in a dramatic spread of new varieties to new villages over a single season (Figure 1).

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\(^1\) from the F\(_2\) to the F\(_5\) generations with minimal selection (Figure 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\(^2\), and when segregation in the next generation is no longer a major complicating factor\(^2\).

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).

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\(^1\) 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.

\(^2\) 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 2.

A schematic diagram of a PPB programme. Breeders control the process until the F₄ generation, then farmers collaborate from the F₅ generation onward. Breeders include selected bulks in formal trials from the F₈ 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 (Figure 3).

**Table:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P₁ x P₂</td>
</tr>
<tr>
<td>1</td>
<td>F₁</td>
</tr>
<tr>
<td>2</td>
<td>F₂</td>
</tr>
<tr>
<td>2</td>
<td>F₃</td>
</tr>
<tr>
<td>3</td>
<td>F₄</td>
</tr>
<tr>
<td>3</td>
<td>F₅</td>
</tr>
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<td>F₆</td>
</tr>
<tr>
<td>4</td>
<td>F₇</td>
</tr>
<tr>
<td>5</td>
<td>F₈</td>
</tr>
</tbody>
</table>

**Figure 3.** An example of collaborative plant breeding where a farmer has grown a bulk for four years in the main season. He intends to continue to grow this variety in 2002. At the F₇ stage the variety can be seen to be phenotypically uniform.

**Kalinga III/IR64 bulk (W Bengal)**

- **F₄** 1998
- **F₅** 1999
- **F₆** 2000
- **F₇ 2001**
- **F₈ 2002**

*Saikya Mahato of Jhabra, W Bengal, in his selected F₇ bulk, kharif 2001*
One great advantage of PPB is that it is much faster than conventional breeding (Figure 4). 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%.

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

*Figure 4.* A comparison of the breeding of rice cultivar Ashoka 228 by participatory methods and the conventional breeding of rice cultivar BD 101.

**References**


Improving the food security of poor farmers: Outstanding new varieties from participatory plant breeding

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Varieties from participatory plant breeding released

Birsa Agricultural University (BAU) in Jharkhand, eastern India, released in May 2001 the first-ever early maturing, high-yielding, superfine rice varieties for rainfed uplands. A maize variety was also released at this time. All three of these varieties were the products of a highly successful participatory plant breeding (PPB) programme. They were bred in a collaborative project, which has been operating since 1997, between the Gramin Vikas Trust East (GVT-E), BAU in Ranchi, Jharkhand, India, and the Centre for Arid Zone Studies, Bangor, Wales.

The higher yields and improved traits of the new varieties can greatly improve the livelihoods of farmers served by the GVT projects in western and eastern India⁴. In the project areas, rice and maize are staple crops, yet many farmers are, at present, unable to meet their own food demands from their own harvest (Figure 1). These new varieties will reduce the gap for such food-deficit households. Some farmers will be able to reduce the area under their staple crops to allow for the cultivation of more nutritious or more profitable ones.

Figure 1. Many farms in Jharkhand state consist of poor-quality land on upland slopes. Farmers rely on rainfall, so in drought years crops can often only survive if fields are close to natural ponds. The fields above have been direct-seeded, but some have been abandoned due to drought.

⁴DFID India and Government of India-funded projects.
Two new upland rice varieties

Farmers of rainfed uplands require varieties that mature in less than 100 days, but still produce a reasonably good yield of grain and fodder. Farmers greatly appreciate early maturity because it shortens the hunger gap and reduces the risks from drought when the rains stop too soon. An early harvest also fetches a higher market price if the farmer sells grain as part of his or her livelihood strategy.

So far, Kalinga III is the only modern upland rice variety that has been accepted by farmers. However, Kalinga III is prone to lodging, particularly if rainfall is high or the fields have above-average fertility. PPB was employed in order to produce something better, and the result was two outstanding rice varieties (Figure 2) that were produced at least twice as quickly as with conventional breeding. Both varieties yield significantly more than Kalinga III but have much better straw strength.

![Figure 2](image-url) Mean grain yield (t ha⁻¹) and time to flower (days) of two Ashoka varieties compared to control varieties in 1999 and 2000. Data were collected from three trials; AICRIP trial at BAU, a BAU trial at the BAU-GVT farm in Ranchi, in kharif 1999, and one trial at the BAU-GVT farm, Ranchi, in kharif 2000.

Ashoka 200F (Birs gram Dhan 109)

Ashoka 200F is the first variety of rice to be developed through collaborative participation – i.e. where the farmer grew the variable bulk in his or her own field and selected within it. The farmer selected plants from the bulk derived from the cross between Kalinga III and IR64. He selected plants that matured early, were tall, high tillering, resistant to lodging, resistant to disease and that had superfine grains. The selected bulk was given to scientists who submitted it to further tests. In research station trials, Ashoka 200F yielded 25% more than Kalinga III and 33% more than Birs Gora. It matures early, after about 86 days, grows about 95 cm tall, and has a better cooking quality than Kalinga III. It performs well in drought-prone, weedy conditions (Figure 3).
Figure 3. Ashoka 200F is an exceptional new rice variety that grows taller and has a much higher yield than local landraces, as seen above. Farmers like its fine grains, white kernels and excellent cooking quality.

Ashoka 228 (Birsar Gramin Dhan 110)

This variety was developed through consultative participation – i.e. where farmers selected among entries grown by researchers on the research station. Local farmers visited the BAU-GVT research farm in kharif 1998 and selected among F4 bulks from a cross between Kalinga III/IR64. The most-preferred bulk, selected jointly by farmers and scientists, was released as Ashoka 228. It is taller than Ashoka 200F (100 cm), and matures slightly later (95 days), but is still earlier than some local varieties. In research station trials it yielded 19% more than Kalinga III and 26% more than Birsa Gora. The cooking quality of Ashoka 228 is even better than that of Ashoka 200F.

The popularisation of these varieties

For varieties to spread informally from farmer to farmer, they need to be obviously better than alternatives. This is clearly the case for the two new Ashoka varieties (see box below).
Why farmers like the new rice varieties

Ashoka 200F and Ashoka 228 have many features that make them appealing to farmers:

- Early maturity
- High yield
- Stiff straw, resistant to lodging
- Tolerance to major pests and diseases
- Long, slender grains (superfine)
- Straw-coloured husks with white kernels
- Excellent cooking quality

However, informal networks are greatly accelerated if the formal sector can supply genetically true-to-type seed to farmers in large quantities. Already these two varieties are under extensive multiplication in the formal sector (Figure 4), and there will be sufficient seed for farmers to grow several thousand hectares of these new varieties in kharif 2002. Within a few years, these varieties could occupy a substantial proportion of the upland rice area in eastern India. These varieties will also be popularised in western India by GVT-West and variety Ashoka 228 is already proving popular for early season rice in Nepal.

Figure 4. A 3.5-acre plot of Ashoka 228 being grown for seed multiplication near Ranchi, Jharkhand. This excellent new variety produces more tillers, and therefore more panicles, than local varieties, which results in a high yield.

A new early maturing maize variety

Most of the farmers in the GVT area grow local varieties of maize, either because improved varieties have been unsuitable for the harsh environment, or because seed is unavailable. GVT has already shown that the replacement of local varieties with higher-yielding ones tremendously increased food security. However, such varieties were of longer duration than local varieties so they increased risk to farmers who often encounter end-of-season drought. Hence, efforts were made in the maize project to develop new varieties of early maturity that would be more suitable for local conditions.
Early Composite (Birsa Gramin Makai 2)

This is the second variety of maize (after GDRM 187 developed by GAU and GVT West) to be released through PPB in India. It was selected from the C3 cycle of random mating of a broadly based population created by crossing three white-grained with three yellow-grained varieties in *kharif* 1997. Farmers were involved in selection, and the population resulting from the C3 cycle was named the Early Composite. It matures in only 77 days and yields about 4.5 t ha\(^{-1}\) grain, which is 9% more than BM1 (the control). In farmers’ fields its yield advantage increases to 19% over BM1 and 44% over the local variety (Figure 5).

![Figure 5. Average grain yield (t ha\(^{-1}\)) of maize varieties in four trials conducted on research stations in Ranchi and BAU and GVT-BAU research farms in *kharif* in 1999 and 2000, and 12 trials conducted on farmers’ fields as PPB trials in Jharkhand and Orissa in *kharif* 2000.]

Why farmers like Early Composite - Birsa Gramin Makai 2

- Early maturity
- Tall plants, with long cobs that grow out of reach of wild animals
- Yellow-flinted grains
- Excellent cooking quality
- Better taste than the local variety
- High stover yield
- Delayed senescence
- Resistance to lodging, leaf blight and sheath blight
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 (Figure 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, 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 (Figure 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

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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) 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.](image)

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).

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Nkaakom</th>
<th>Aworowa</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>W</td>
<td>Rank</td>
</tr>
<tr>
<td>Stem diameter</td>
<td>57</td>
<td>51</td>
<td>1</td>
</tr>
<tr>
<td>Branching</td>
<td>64</td>
<td>37</td>
<td>1</td>
</tr>
<tr>
<td>Canopy formation</td>
<td>72</td>
<td>38</td>
<td>1</td>
</tr>
<tr>
<td>Healthy/green leaves</td>
<td>34</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td>Soil cracking</td>
<td>5</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Suitability for intercropping</td>
<td>2</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>Resistance to lodging</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Times mentioned (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nkaakom</td>
</tr>
<tr>
<td>Tuber yield</td>
<td>100</td>
</tr>
<tr>
<td>Branching</td>
<td>33</td>
</tr>
<tr>
<td>Big stem</td>
<td>33</td>
</tr>
<tr>
<td>Tuber shape</td>
<td>5</td>
</tr>
<tr>
<td>Weed suppression</td>
<td>18</td>
</tr>
<tr>
<td>Healthy leaves</td>
<td>7</td>
</tr>
<tr>
<td>Suitability for intercropping</td>
<td>14</td>
</tr>
<tr>
<td>Marketable size</td>
<td>2</td>
</tr>
<tr>
<td>Neck length of tubers</td>
<td>5</td>
</tr>
<tr>
<td>Tuber skin colour</td>
<td>3</td>
</tr>
<tr>
<td>Resistance to lodging</td>
<td>2</td>
</tr>
<tr>
<td>Early maturity</td>
<td>5</td>
</tr>
<tr>
<td>Non-rotten tubers</td>
<td>0</td>
</tr>
<tr>
<td>Drought tolerance</td>
<td>1</td>
</tr>
<tr>
<td>Disease resistance</td>
<td>1</td>
</tr>
</tbody>
</table>

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.
Onward and outward – strategies and partnerships for the promotion of on-farm seed priming

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Background

The concept of on-farm seed priming – soaking seed in water before sowing – has come a long way in a short time. The initial PSP-funded project *The development and testing of seed priming to improve stand establishment, early growth and yield of crops in semi-arid Zimbabwe and India* only began in earnest in 1996. However, it quickly became clear that this simple, key technology resulted in substantial yield benefits in a wide range of crops and was enormously popular with farmers who had tried it for themselves. The evidence from hundreds of participatory trials showed that priming seed typically gave benefits more than 85% of the time (Figure 1). Occasionally, there was no response but, since the practice didn’t cost much and was almost never detrimental, farmers didn’t mind that. A particularly apt analogy for seed priming is that of an insurance policy, but one that often gives a bonus.

Figure 1. Farmers’ views on seed priming are essential, and trials are conducted only after extensive surveys. So far, seed priming has produced benefits most of the time.

Priming was effective in India and Zimbabwe for a number of crops; for example maize, upland rice and chickpea, and *in vitro* studies in Bangor suggested that many other crops would also respond positively in the field.

Farmer participation

Farmers and researchers in a wider range of crops and countries were to be encouraged to test priming for themselves. This project, *Participatory promotion of on-farm seed priming*, concentrated on the participatory approach that had proved to be so successful in Zimbabwe and India (Figure 2). It was a ‘process’ project that consisted of an
extensive dissemination exercise involving project scientists, PSP managers and DFID itself. The purpose of this exercise was to sensitize scientists, extension workers, NGOs and others to the advantages of seed priming, and to persuade them to implement participatory trials with collaborating farmers. The PSP role is to:

- **Disseminate results.** This is being done by publishing refereed journal articles, making presentations at meetings, workshops, conferences, etc., and producing summary materials for the popular press and radio. A website, [www.seedpriming.org](http://www.seedpriming.org), is being maintained. All these outputs are targeted towards people who are working in agricultural situations in which priming could make a difference.

- **Persuade more collaborators to consider seed priming, and to provide technical support and funding where necessary.** The project funds low-cost, but large-scale, work involving hundreds of farmers in Bangladesh, Cameroon, Gambia, Ghana, India, Nigeria, Nepal, Pakistan, Sierra Leone, Thailand and Zimbabwe. In addition, many organisations are trying seed priming as a result of our dissemination efforts, using their own resources. Examples of this are: World Vision International in a range of countries in Africa; ICRISAT in Zimbabwe and Tanzania as part of their involvement in Farmer Field School programmes; and rural development projects such as the Aga Khan Rural Support Project and the Sarhad Poverty Reduction Project in Pakistan.

*Figure 2.* Group evaluations have been invaluable for testing and promoting uptake of seed priming in countries such as Zimbabwe.
Other PSP projects have included seed priming as part of their activities. *Promotion of chickpea following rainfed rice in the Barind area of Bangladesh* showed that priming was the key technology that would make chickpea production an attractive proposition for farmers who would otherwise have left their land fallow after harvesting one crop of rice (Figure 3). The realisation that a combination of short-duration varieties, rapid minimal tillage and seed priming could enable the production of a second crop without irrigation prompted the development of *Promotion of rainfed rabi cropping in rice fallows of India and Nepal: Pilot phase*. This is a project in which the constraints and opportunities for growing a second crop on residual soil moisture are being evaluated at a range of sites in Eastern India and Nepal.

Several of the PSP-funded Participatory Crop Improvement (PCI) projects have tested and promoted on-farm seed priming, to exploit any synergies between new varieties and priming. For instance, many of the PVS trials in *Participatory rice variety improvement in Ghana II* include simple comparisons of priming. Researchers and farmers in *Participatory crop improvement in high-potential production systems and salt-affected areas of Patiala district of the Punjab State* are exploring the effect of priming wheat seed and its interaction with minimum tillage and fertiliser use efficiency. Similarly, PCI projects in Gujarat and Nepal are testing priming of various crops in on-farm trials.

*Figure 3. Widespread replacement of rice fallows by chickpea using seed priming in Bangladesh.*

**Research into mechanisms**

Another project, *The physiological basis for the effects of on-farm seed priming in tropical crops: Interactions with seedbed physical conditions and nutrient dynamics*, implemented by Silsoe Research Institute, is using a combination of laboratory studies in the UK and field experiments in Zimbabwe to look at the mechanisms responsible for the seed-priming effect. While farmers are pleased with the performance of seed priming in their fields, it was not clear to researchers just what mechanism was responsible for these benefits. This project has shown that, for maize, the effects of priming are most apparent when seedbeds are drying rapidly. Current work is exploring the interaction between priming-induced vigour and seedbed nutrient dynamics.
**Extension approaches**

Experience has shown that approaches to new technology differ between research scientists, government extension agencies and NGOs working directly with farmers. NGOs seem willing to consider and, more importantly, act upon, evidence gathered elsewhere. Their priority is to provide their farmers with something that might be useful. In contrast, the linear relationship between research and extension is generally more rigid in government systems. Here, researchers are often reluctant to pass on technology for extension until it has been tested on research stations for a number of years. In such cases, multi-organisation approaches have been very effective, so that parallel activities can be maintained and effective feedback from farmers obtained at the earliest opportunity. A good example of this is the collaboration between PROVA (an NGO), the Bangladesh Agricultural Research Institute, and the Department of Agricultural Extension in three Districts of Bangladesh to test and promote chickpea and seed priming (Figure 4). There has been widespread adoption by farmers of chickpea production technology, while researchers have been able to generate data on agronomic performance and physiological mechanisms.

*Figure 4. Average yield increase in farmers’ fields due to priming chickpea in Bangladesh was 50% in 1998/99, 20% in 1999/00 and 50% in 2000/01. As expected in all multi-site, paired-plot comparisons, a few trials gave negative results due to error variance.*

The simplicity of seed priming is a major factor in persuading farmers to adopt it. In contrast, this simplicity is a drawback in persuading extension agencies to promote it with farmers. It seems to be difficult to justify the allocation of major operational resources to promoting seed priming alone. The initial benefit of seed priming, that of obtaining a good stand of vigorously growing seedlings, cannot be viewed in isolation. Such stands are the starting point for any subsequent interventions to improve crop production. Thus it is reasonable to suggest that priming should be included as an element of an extension ‘package’, although the drawbacks with the package approach have been well documented.

It is likely that future work on seed priming will focus more on its role as a key technology in a farming systems context. The initial work in India showed that the effects of priming seeds can influence not just that crop but also following crops and hence the whole cropping system. This has been confirmed more recently by the work in Bangladesh and Pakistan. The dissemination and promotion approach described above has spawned a large network of people involved in seed priming and this will be continued and expanded.
The system of rice intensification (SRI) in Bangladesh and Nepal

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The system of rice intensification (SRI) is a way of growing rice that was first developed in Madagascar between 1961 and 1995 by Fr. Henri de Laulanie. It combines early transplanting using very young seedlings, wide spacing, and the maintenance of an aerobic soil environment by careful control of flooding. Substantial yield increases from SRI have been reported, which are ascribed to greater tillering per plant and more filled grains per panicle than in conventional methods.

In turn, these benefits are said to be the result of minimising the ‘shock’ normally associated with transplanting (by using younger seedlings and placing roots more carefully during transplanting) while maximising capture of light and nutrients (by spacing the plants more widely and by allowing more oxygen into the root zone by careful irrigation). Preliminary trials by Bangladeshi farmers, in collaboration with researchers from CARE-Bangladesh, during the 2000 early (Boro) season had shown that average yield increased by 30% and was, indeed, associated with better tillering and more grain per panicle.

During the 2001 Boro season, CARE-Bangladesh implemented more trials with additional support from PSP. These trials were designed to disaggregate elements of SRI to evaluate how much of the benefits were due to the age of seedlings at transplanting and how much were due to plant spacing. A series of trials was also implemented in Nepal (project R7542) to evaluate elements of the SRI system in the 2001 Chaite (equivalent to the Boro) season and in the following main season.

In Bangladesh it was found that most of the yield benefit, at relatively high yield levels (between 5 and 7 t ha⁻¹) was due to transplanting younger seedlings, whereas yield from the planted area tended to decline as spacings became wider. In Nepal, where yields were much lower (between 3 and 4 t ha⁻¹) there were no significant differences in yield between SRI and the farmers’ normal practice. Farmers in both countries reported greater use of labour with SRI, mostly for the extra weeding required when flooding is less and spacings are wider. Weeding is a major input and extra expenditure on it is a serious issue for farmers.

In Bangladesh, where higher levels of management and greater control of irrigation water are found, farmers expressed enthusiasm for SRI and intended to try it again in the next season. In contrast, farmers in Nepal reported that they would use younger seedlings to transplant but would use conventional spacings and, probably, more flooding to control weeds and so reduce the amount of weeding to be done.

The complete SRI package is very demanding, both in terms of management expertise and of labour. The use of younger seedlings, transplanted carefully, was popular in both countries, whereas opinions of the merits of wider spacing were more varied. It is likely that uptake of elements of the SRI package could prove beneficial in improving yield, but the elements selected by farmers will vary with the farming system. This
demonstrates the value of participatory research: instead of a recommendation of a standard practice by researchers, farmers adapt the technology to suit their own particular circumstances.