Maize varieties picked by farmers for farmers in western and eastern India

RIU

Validated RNRRS Output.

Tribal hill farmers in Gujarat, Madhya Pradesh and Rajasthan in western India, and Jharkhand, Orissa, and West Bengal in eastern India, helped select and test maize specifically for these areas where droughts are frequent and soils are poor. The new varieties have spread over thousands of hectares because they were picked by farmers for farmers. They are earlier than the strains they used previously, they're drought-tolerant, and meet preferences for taste and cooking quality. Plus, they intercrop well with important later crops such as horsegram and blackgram. These new maize varieties have major potential to improve the lives of small farmers who can't irrigate their crops: around two-thirds of the population in these hill areas.

Project Ref: **PSP15:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **CAZS-NR, UK**
Source: **Plant Sciences Programme**

Document Contents:

Description

PSP15

Research into Use
NR International
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Geographical regions included:

India,

Target Audiences for this content:

Crop farmers,

A. Description of the research output(s)

1. Working title of output or cluster of outputs.
In addition, you are free to suggest a shorter more imaginative working title/acronym of 20 words or less.

Client-oriented breeding in maize - improved varieties GM-6 for western India and BVM 2 for eastern India

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

Plant Sciences Research Programme and DFID India bilateral projects

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RiUP activities.

R8099, Programme Development

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*4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? **(max. 400 words)**. This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

Early-maturing and **drought-tolerant maize varieties** bred by **client oriented breeding (COB)** for **western** and **eastern India** (Table 1). The new COB varieties are adapted to low input and drought conditions but they respond to higher inputs and better conditions. The earlier maturity of the new varieties provides grain and fodder earlier in the season and this shortens the hunger gap. The new varieties are very suitable for selling green cobs in the market very early in the season (Table 1). The new varieties have good cooking quality and taste.

There are many other varieties produced from COB programmes in the west and the east that are at an advanced stage of testing including varieties with higher essential amino acid content and high oil content.

Table 1. Characteristics of two released maize varieties bred by COB in western and eastern India

Variety	Description
GM-6 and **BVM 2**	• Very early maturity (75-80 d) with high drought tolerance • High grain and fodder yield, flint grains with good cooking quality and taste, resistance to lodging and diseases • Respond to better conditions.
GM-6	• Released in Gujarat in 2001, in Rajasthan and MP in 2005 • White grained
BVM 2	• Released in Jharkhand in 2003 • Yellow grained

Client-oriented maize breeding (COB) (Witcombe et al., 2005) was started in western India in 1993 and in eastern India in 1997. In western India a base population was developed by random mating of varieties preferred by farmers in **participatory varietal selection (PVS)** (Joshi and Witcombe, 1998) trials. Farmers were involved in selection in the segregating generations of COB and in testing the outputs using participatory varietal selection (Witcombe et al., 2003). A similar process was followed in eastern India in Jharkhand, West Bengal and Orissa (Virk et al., 2005). Varieties were produced from 1997 to 2005 in western India and from 1999 to 2004 in eastern India**.**

Problem addressed:
In western India, maize is the most important crop of tribal farmers in hill districts of western India in Gujarat, Madhya Pradesh and Rajasthan (Fig. 1). Maize is the second most important crop after rice in Jharkhand, Orissa and West Bengal. In both regions the crop is grown on low fertility soils on undulating land under rainfed conditions where severe droughts are frequent.

Low-resource farmers grow low yielding and disease susceptible old varieties of maize or local varieties because of lack of suitable modern varieties (Joshi et al., 1998; Witcombe et al., 1998). Most of the released varieties are not adopted by farmers because they do not suit drought-prone, low fertility conditions.

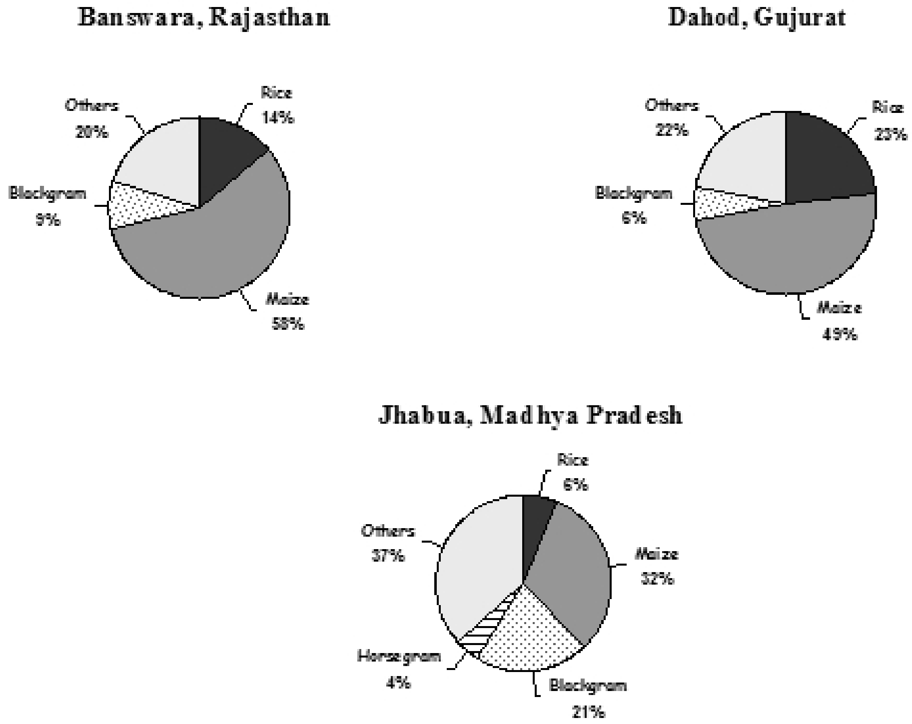

Fig. 1. Crops (as percentage of total cropped area) in the rainy season in three districts of western Indian, 2004.

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	***Technology***	***Service***	***Process or Methodology***	***Policy***	***Other Please specify***
x			*x*		

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment

The main commodity is maize. In western India the early-maturing maize varieties are more suitable for intercropping than later varieties as they are less competitive. Intercrops include horsegram and blackgram (PSP dossiers 8 and 14) and pigeonpea. In eastern India the maize crop is sometimes intercropped with blackgram and pigeonpea.

The process of COB, tat includes the technique of participatory varietal selection (PVS) can be applied to any crop (PSP dossiers 33 and 34).

7. What production system(s) does/could the output(s) focus upon?

Please tick one or more of the following options. Leave blank if not applicable

Semi-Arid	***High potential***	***Hillsides***	***Forest-Agriculture***	***Peri-urban***	***Land water***	***Tropical moist forest***	***Cross-cutting***
x							

8. *What farming system(s) does the output(s) focus upon?*
   Please tick one or more of the following options (see Annex B for definitions).
   Leave blank if not applicable

Smallholder rainfed humid	***Irrigated***	***Wetland rice based***	***Smallholder rainfed highland***	***Smallholder rainfed dry/cold***	***Dualistic***	***Coastal artisanal fishing***
x				*x*		

9. *How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**). Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.*

The introduction of new varieties of maize in the rainfed conditions can be linked with the rainfed *rabi* fallow projects (PSP dossier 35) where the maize varieties can be followed by the cultivation of pulses. It can be combined with seed priming (PSP dossiers 28 and 30). The new maize varieties can also be intercropped with improved legumes. For example, there is a synergy between maize and horsegram where an intercrop of improved maize (GM-6) with improved horsegram (AK-42, IVH-1 and IVH-2) is much more attractive than intercropping maize with horsegram landraces (PSP dossiers 8 and 14).

In PVS, the new intervention is a crop variety which can combine with the testing of other interventions that are synergistic with new crop varieties, i.e., crop protection and improved crop agronomy interventions. Since farmers evaluate varieties for all traits including fodder quantity and quality then clustering with outputs relating to improved livestock nutrition would be synergistic.

Clustering can be done with the following RNRRS outputs:

CPP, Good seed initiative, R8480
CPP, Increasing food security and improving livelihoods through the promotion of integrated pest and soil management in lowland maize systems Phase II, R8452, R8215
CPP, Linking demand with supply of agricultural information, R8429, R8281
CPP, Strategies for feeding smallholder dairy cattle in intensive maize forage production systems and implications for integrated pest management, R7955
NRSP, Participatory Technology Development, R7412

Validation

B. Validation of the research output(s)

***10. How** were the output(s) validated and **who** validated them?*
*Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation **(max. 500 words)**.*

The COB varieties were developed by involving farmers in the selection in segregating generations. In addition, farmers conducted participatory varietal selection (PVS) trials immediately the new varieties were ready for testing.

The PVS trials were conducted by the resource poor in villages where GVT was working. Farmers conducted mother and baby trials (Witcombe, 2002). In the mother trials farmers grew the complete set of varieties and in baby trials just one variety to compare with their local variety. All farmers' trials were conducted under farmers' own management. The on-farm trials were jointly evaluated for the quantitative and qualitative traits using household level questionnaires and focus group discussions.

In western India, Farmers collaborated with researchers from GVT and three State Agricultural Universities. State departments of Agriculture were involved to a limited extent. Further validation is being undertaken during the process of seed provision to farmers by:
Catholic Relief Services (CRS) in Rajasthan, Gujarat and MP;
Madhya Pradesh Rural Livelihood Project (MPRLP) and the Action for Social Advancement (ASA) in MP;
SEWA MANDER in Rajasthan,
SARTHI, PRYAS, the District Rural Development Agency (DRDA), and the National Watershed Mission in Gujarat.

GM-6 was validated in research and on-farm trials in Gujarat (Table 2). It was later tested in Rajasthan and Madhya Pradesh in more trials that led to its recommendation in these two states. The new 'BVM' varieties were validated in on-station trials, AICMIP trials and on-farm PVS trials (Table 2).

GM-6 yielded 10-29% more than the local check in on-farm trials (depending on the year) and 9-21% more than the modern variety check on-station (Table 2). It was 13 days earlier to mature than the local check in farmers' fields in 2000.

In Eastern India, farmers collaborated with researchers from GVT and Birsa Agricultural University, Ranchi in on-farm validation. Research station trials were done by BAU and All India Coordinated Maize Improvement Project (AICMIP) of the Indian Council of Agricultural Research (ICAR). The State Departments of Agriculture in Jharkhand has also tested the variety.

BVM 2 gave 17% higher grain yield over the modern check variety and 42% over farmers' local in trials conducted from 1998 to 2005 (Table 2). Increases for the other varieties in eastern India over the modern check variety were up to the level of 28% in on-farm trials. In the research trials COB varieties were 5 to 12% superior to modern check variety (Table 5). Grain yield increases for COB varieties over the best national check in the AICMIP trials were 11 to 22% depending on the year.

In both eastern and western India the yield increases from the COB varieties tended to be higher in farmer field conditions than in the research station trials because the new varieties have better adaptation to poor fertility fields.

Table 2. Details of testing of GM-6 in western India, 1997 to 2004 and BVM 2 in eastern India, 1998 to 2005

When tested	Where tested	Tested by	Research trials (No.)	On-farm trials (No.)	Grain yield increase (% over check)
GM-6					
1997, 98	Guj	GAU	8	-	21 over GM 1
1998	Guj, Raj	GVT	-	19	29 over local
2000	Raj	GVT	-	16	16 over local
2002 to 2004	MP	JNKVV GVT	6	-	9 over local
			-	25	10 over local
BVM 2					
1998-2005	Jharkhand, Orissa, W. Bengal	GVT, BAU	-	190†	17 over BM 1; 42 over local
1999-2003	Jharkhand	BAU, GVT	9	-	9 over BM 1
2000-2002	All India	AICMIP	38	-	12 over Surya

† Includes front-line demonstrations.

The new varieties also excelled in a number of other traits than grain yield particularly in the earlier maturity, drought tolerance and grain and cooking quality (Table 3). Both GM-6 and BVM 2 can be grown as baby corn due to their earlier maturity and good ear size. Farmers around Ranchi who grew it for this purpose in 2006 have reported high profits and are keen to start commercial cultivation.

Table 3. Some of the additional features of new varieties

Name of output	Special features
Western India	
GM-6	Early maturity, escaping terminal drought, white-flint seeded with high cooking quality, lodging tolerant, fully husked ears that avoid diseases and insects, responds to high fertility
Eastern India	

BVM 2	First COB variety released in Jharkhand in 2003; Extra early to mature (75-80 d); high grain quality (high tryptophan content). It is also good baby corn. Drought, lodging and disease resistant.

*11. **Where and when** have the output(s) been validated? Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above **(max 300 words)**.*

The outputs were validated in the semi-arid system of smallholder from 1997 to 2005 in rainfed dry systems. All testing was carried out under rainfed conditions mainly on sloping, low-fertility fields in the uplands.

The target groups of farmers were mainly the resource-poor farmers in the villages of western and eastern India where GVT was working. The work in western India was centred on adjoining areas of three western Indian states; eastern Gujarat, southern Rajasthan and western Madhya Pradesh in the districts of Jhabua (MP), Panchmahals (Gujarat) and Banswara (Rajasthan). About 0.7 M people live there.

The work in eastern India was targeted for 13 districts of Jharkhand (Ranchi, Palamu, Hazaribagh, West Singhbhum, Kharsavan, Goda, Gumla, and Bukaro), Orissa (Dhenkanal, Keonjhar, Mayurbhanj) and West Bengal (Midnapur and Purulia) for improvement of livelihoods of 0.4 M people.

Farmers that were targeted were indigenous peoples typically having smallholdings with little or no irrigation facilities, who are food deficit and poor (as about 65% households live below the poverty line) and have agriculture as one of the most important enterprise in their livelihood strategies. Seeds were provided to all categories of male and female farmers (resource-rich and resource-medium). The varieties were then evaluated by the farmers that grew the trials, and their male and female neighbours, friends and relatives, for pre-harvest traits such as fodder yield, earliness, various plant and ear traits. The evaluation of the post-harvest traits always involved women.

Current Situation

C. Current situation

*12. **How and by whom** are the outputs currently being used? Please give a brief description **(max. 250 words)**.*

In western and eastern India the varieties are being grown by farmers that have maize either as a staple or a major part of their diets. They are growing the varieties in place of the landraces they previously cultivated. They utilise the crop for grain that, even when it is a staple, is often sold to raise urgently needed cash. The maize stover is a major source of animal feed. Many of the farmers maintain the variety they have been given from farm-saved seed, provided the initial seed quantity was adequate and also distribute seed to other farmers as a gift, exchange or by a cash transaction.

Maize is a cross-pollinated crop so even when farmers report that they are no longer growing a named variety they have tried, such as GM-6, it may well still be being used by them. An improved maize variety can make a big genetic contribution to the following crop not only because of cross pollination to the farmers' landraces but because some of the seed the farmer sows originates from the plants of the variety. This genetic contribution is, overall, probably very important in improving productivity but extremely hard to quantify.

The lessons concerning the process of COB in maize are being used to varying extents by the collaborating plant breeders from the four state agricultural universities. They are continuing to use the outputs in their programmes as source material and for seed multiplication and dissemination.

*13. **Where** are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used **(max. 250 words).***

In western India GM-6 has primarily been used in Gujarat where it was first released; for several years Gujarat Agricultural University (GAU) and GVT provided seed of this variety mostly in Panchmahals district. More recently, GM-6 was tested in MP and Rajasthan and in both states has now been recommended for cultivation for hilly areas (primarily Banswara district in Rajasthan, and Ratlam and Jhabua districts in MP). Hence, GM-6 is now in at the beginnings of the official seed production chain in these two states.

BVM 1 is being used in the rainfed uplands of Jharkhand, Orissa, and W. Bengal, India in eastern India by a very limited number of farmers and GOs because of constraints on seed supply. Since BVM 2 is a released variety it is in the chain of seed production but very little seed is being produced.

*14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading **(max 250 words).***

The scale of current use has not been estimated but it must be considerable in western India as the acceptance of GM-6 is high. From a survey we found that all the farmers given access to seed of GM-6 grew it in the first year in 2001 (Figure 2). After the first year a proportion of the farmers decided to no longer grow the variety. However, those that did decide to grow the variety again became continuing adopters and grew it on an increasing proportion of their maize land. The most probable explanation for this pattern is that the first farmers try the variety some do not prefer it while others that like it fail to save seed. Once farmers had grown it for a second time, all were convinced of its advantages.

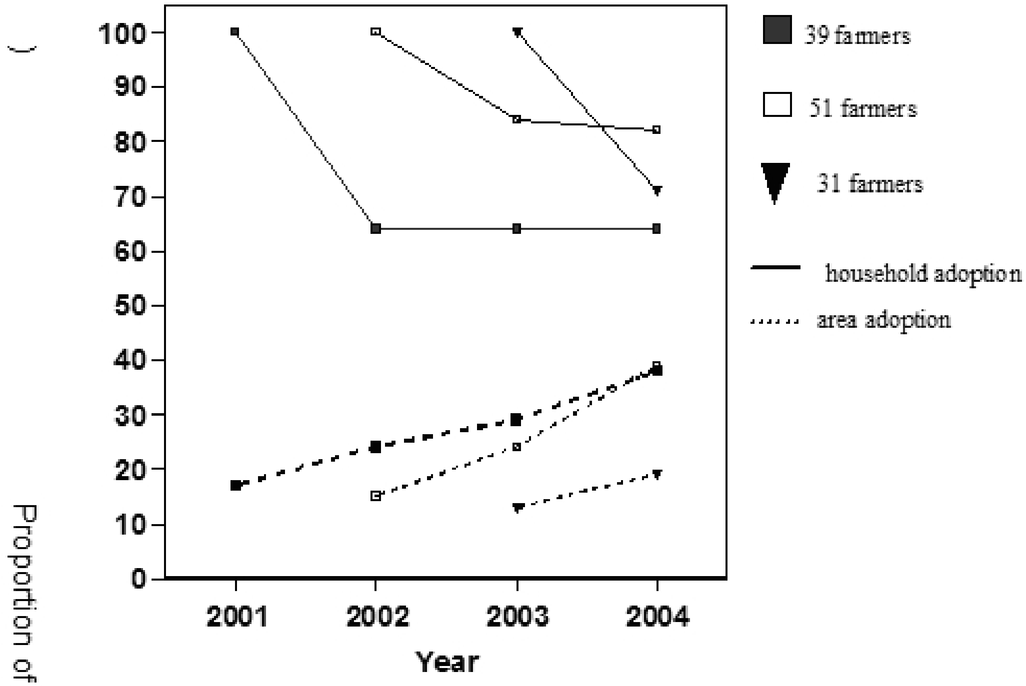

Figure 2. Adoption as a percentage of farmers who had been given seed of GM-6 and the proportion of maize land they devoted to this variety.

The high adoption patterns of GM-6 are clear from the 121 farmers given seed in 1998 (Table 4).

Table 4. Adoption of GM-6 in the rainy season of 2000 by farmers who were given 5 kg seed for testing in 1998 in Gujarat state

Villages	No. of farmers	Average proportion of farmers who continued to grow (%)	Average area of maize land devoted to GM-6 (%)	Average area of maize land devoted to GM-6 (ha)
13	121	54	38	0.31

Given this acceptance and the scale of promotion (see below) the scale of use is high and is measured in thousands of hectares. It also seems, from positive data on seed distribution from farmer-to-farmer that the variety is still spreading without the continuing supply of seed that is taking place.

15. In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you *see as the key facts of success?* ***(max 350 words).***

In western India, the main activities for dissemination of seed have been through projects such as the western India rainfed farming (WIRFP) which has now completed. Ongoing projects include the Madhya Pradesh Rural Livelihoods Project (MPRLP) and Poverty Initiative Programmes (DPIP), National Watershed Programme and Community Resource Centres under District Rural Development Agency. Other GOs and NGOs that have assisted include: State Departments of Agriculture, KVKs; CRS (Jhabua), World Vision (Banswara), Dahod Cooperative Sangh (Dahod), Prikirti Foundation (Dahod), UTHAN (Limkheda, Guj), PRYAS (Dahod), SARTHI (Santrampur, Guj), SEWA MANDIR (Udaipur), DRDA (Dahod); ASA (Bhopal).

In eastern India, apart from GVT and BAU, seed of BVM 2 was supplied to the following in 2006:

- North-East Hill Centre, Tripura
- Social Welfare Centre, Chhattisgarh
- Assam Agricultural University
- Maize Research Station Kangara, HP
- Western Orissa Rural Livelihood Project (WORLP) that is DFID funded

GVT has collaboration with about 30 NGOs in Jharkhand, Orissa and West Bengal who may have assisted (it is difficult to document as many packets of seed have been distributed). These include the Poorest Area Civil Society Programme (PACS) of Govt India and supported by DFID. The village Panchayats, Krishi Vigyan Kendras, National Agricultural Banking for Rural Development (NABARD), National Agricultural Marketing Federation (NAFAD), Council for Advancement of People’s Action and Rural Technology (CAPART).

Capacity strengthening in the following is required:

- Capacity building by training to GOs, GOs and farmer groups.
- Capacity in creating awareness with the stakeholders through meetings, demonstrations and the publication of literature for:
    - the new varieties
    - the maintenance of quality seed of maize varieties from farm-saved seed.

Current Promotion

D. Current promotion/uptake pathways

*16****. Where*** *is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion* ***(max 200 words).***

GM-6 has been promoted in western India in Gujarat, Rajasthan and MP. To date the scale of promotion was sufficient to sow about 3000 ha (Table 5). The total area of maize in western India in Gujarat, Rajasthan and MP is 0.35 M ha in the districts where GVT is working. For a replacement rate of 10% of the maize area every year there is an annual demand for 900 t assuming a seed rate of 20 kg ha $^{-1}$. This remains modest even if multiplied by 10 to account for likely expansion from farm-saved seed and farmer-to-farmer seed distribution.

Table 5. Quantity of seed of GM-6 distributed in the rainy seasons from 1999 to 2006 in western India by GVT

Year	State	Quantity to farmers (kg)	Quantity to GO, NGOs† (kg)	Sufficient for (ha)
1999	MP	30		1
1999	Guj	505		20
2000	MP	100		4
2000	Guj	1030		41
2001	MP	200		8
2001	Raj	450		18
2001	Guj	895	360	50
2002	MP	1940		78
2002	Raj	2170		87
2002	Guj	5752	400	246
2003	MP	6680	350	281
2003	Raj	8000		320
2003	Guj	9915	2690	504
2004	MP	11850		474
2004	Raj	2100		84
2004	Guj	1250		50
2006	MP	20000		800
2006	Guj	450		18
Total		**73317**	**3800**	**3084**

†See question 15 for these organisations.

The total area under maize in Jharkhand, Orissa) and W. Bengal is about 0.29 M ha. Using similar assumptions made for western India there is an annual seed demand of about 600 t of seed but dissemination of BVM 2 has been much less. In 2002, 4 t of seed (about 500 g of seed per farmer) distributed in Jharkhand, Orissa and W. Bengal by GVT. About 10% of the farmers are still growing BVM 2 from their own seed.

17. What are the current barriers preventing or slowing the adoption of the output(s)? Cover here institutional issues, those relating to policy, marketing, infrastructure, social exclusion etc. ***(max 200 words)****.*

The promotion of varieties in these poor parts of western India has been inefficient as the areas are remote, the purchasing capacity of the farmers is low, and the demand for seed unpredictable because it varies with the rains. Farmers also have limited access to the government extension services. They are supposed to visit the local farm science centre (KVK) but few farmers have the resources to do so. Front line demonstrations by Departments of Agriculture are few and conducted in more favourable agricultural environments.

There is a long gap between release and dissemination in the GOs sector. Despite the release of GM-6 in Gujarat in 2001 little seed was initially produced by Gujarat Agricultural University. This was because of lack of seed orders (indents) because of lack of awareness of the new variety by the Department of Agriculture and no regard to the demand from farmers. Variety BVM 2 was released in 2003 but no certified seed was produced by BAU because it was not notified till 2005. For the first time its breeder seed is being produced in 2006 and some certified seed can be produced in the dry season for cultivation in 2007.

18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues ***(max 200 words).***

The most important factor to remove the barriers is to raise awareness of them at all levels (State Agricultural Universities, NGOs, Departments of Agriculture and the private sector). There is a lack of awareness of the new technologies but also a lack of awareness on the constraints to delivering them. This would also require the need to package the availability of all of the technologies (see for example Witcombe and Yadavendra, 2006).

There is one major remaining platform in western India, the MPRLP, and in eastern India WORLP. Like all rural development programmes, these are multifaceted and hence a focus on an important single issue such as the provision of new seed can be blurred. There is a need to raise awareness in these two major platforms of the scope for poverty alleviation presented by GM-6 and BVM-2.

In addition to awareness, the following will help in removing some of the barriers. Capacity building:

- for NGOs and private seed companies to take up truthfully labelled seed production.
- for community-based seed production for a more local and sustainable seed supply (see PSP dossier 36). The capacity of self-help groups to have profitable, private-sector linked seed ventures needs to be built up.
- for the integration of the COB approach in maize breeding programmes of the SAUs in western and eastern India.

19. What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people? ***(max 300 words).***

Using Rogers (2003) diffusion of information as a framework for the lessons learnt:

1. The relative advantage of a technology compared to what it is replacing;

This is extremely high. The replacement of old varieties produces very large increases in grain yield and quality of grain in a staple crop. It also adds immensely to the attractiveness of a new cropping system because early maize varieties are more suitable for intercropping with horsegram.

2. The compatibility of the technology with existing systems and ways of doing things, which is closely related to culture;

The compatibility of these technologies is extremely high and allows people to continue with there traditional farming systems.

3. The complexity of the technology in terms of what people need to learn to make it work;
The complexity is very low. The adoption of new varieties does not entail any change in farmers' practice. The COB process is simple but it needs a big change in mindset to make it work effectively.

4. The observability of a technology in terms of how easy it is to demonstrate and observe performance;
The observability is high.

5. The trialability of a technology in terms of how easy it is to test it before deciding to adopt.
The trialability is very easy as long as seed is available. Farmers can test the new variety alongside their customary variety without changing their management of the crop.

Hence, provision of a sustainable seed supply is the most important factor in getting this research into use.

Impacts On Poverty

E. Impacts on poverty to date

20. Where have impact studies on poverty in relation to this output or cluster of outputs taken place? This should include any formal poverty impact studies (and it is appreciated that these will not be commonplace) and any less formal studies including any poverty mapping-type or monitoring work which allow for some analysis on impact on poverty to be made. Details of any cost-benefit analyses may also be detailed at this point. Please list studies here.

Impact studies on poverty were primarily conducted in western India through surveys. The following studies are relevant.

Yadavendra, J.P. and Witcombe, J.R. 2006. The impact of new maize and rice varieties on the livelihoods of poor farmers in marginal agricultural areas of western India. Paper presented in International Symposium on Participatory Plant Breeding, 17-19 June 2006 at M.S. Swaminathan Research Foundation (MSSRF), Chennai.
Witcombe, J.R. and Yadavendra, J.P. 2006. Cultivating partnerships: Better choices for rainfed farming. Gramin Vikas Trust, India, pp.1-24.
Yadavendra, J.P., Patel, V.P. and Witcombe, J.R. 2006. The impact of new maize and rice varieties on the livelihoods of poor farmers in marginal agricultural areas of western India. Paper presented in the Livelihoods Summit, Udaipur, Sept. 27-30, 2005. In: Livelihoods- as if the poor matter, Indian Farm Foresty Development Corporation (IFFDC) New Delhi, pp. 36-37.

Surveys were made in 26 villages with 130 farmers in MP, Rajasthan and Gujarat districts of the GVT project where the project had been working for several years.

Economic benefit of supply of seed of GM-6 to farmers:
Economic benefits from the commercial seed supply to farmers would produce huge economic benefits for farmers (Table 6). The supply of 200 t of seed instead of 25 t of seed would cost an additional £37,000 even if this seed is all given to farmers free of charge, but generates an additional benefit to farmers of over £1 million pounds.

Table 6. The benefits to farmers of growing GM-6 maize from varying quantities of initial seed supply.

Quantity supplied (t)	**Production cost (£)**	**Area year 1 (ha)**	**Benefit year 1 (£)**	**Area year 2 (ha)**	**Benefit year 2 (£)**	**Area year 3 (ha)**	**Benefit year 3 (£)**	**Approx NPV (£)**
25	5,357	1,250	29,464	3,125	55,246	7,813	74,581	153,934
50	10,714	2,500	58,929	6,250	110,491	15,625	149,163	307,868
100	21,429	5,000	117,857	12,500	220,982	31,250	298,326	615,737
150	32,143	7,500	176,786	18,750	331,473	46,875	447,489	923,605
200	42,857	10,000	235,714	25,000	441,964	62,500	596,652	1,231,473

Assumptions
Seed costs of 15 Rs/kg.
Farmers get 5.5 Rs/kg for their additional harvest (an early harvest gives a higher price than the usual 5 Rs/kg).
Local variety yields 1 t ha^{-1} and GM-6 yields: 30% more in year 1; 25% more in year 2; and 15% more in year 3 (variety performance is pessimistically assumed to decline at this rate as it becomes less pure).
The variety spreads within farm and from farmer to farmer and increases in area at 2.5 times a season.
Drought will reduce this rate and emphasises the need of a continuous seed supply (This can also be modelled but has not been done here).
Benefits are discounted at 10% per year after year 1.

21. Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s) ***(max. 500 words):***

- *What positive impacts on livelihoods have been recorded and over what time period have these impacts been observed? These impacts should be recorded against the capital assets (human, social, natural, physical and, financial) of the livelihoods framework;*
- *For whom i.e. which type of person (gender, poverty group (see glossary for definitions) has there been a positive impact;*
- *Indicate the number of people who have realised a positive impact on their livelihood;*
- *Using whatever appropriate indicator was used detail what was the average percentage increase recorded*

Positive effects of new varieties: Farmers' perceptions for GM-6 showed that significantly more farmers preferred the new variety for earlier maturity, higher grain yield, higher fodder yield, better eating quality and higher market price over the local variety (Fig. 3). Although a considerable proportion of the farmers reported that the variety had better eating quality, this was not reflected in market price where the variety was reported to fetch the same price as the local variety. This reflects the market where grain merchants and consumers do not distinguish between different qualities of white maize.

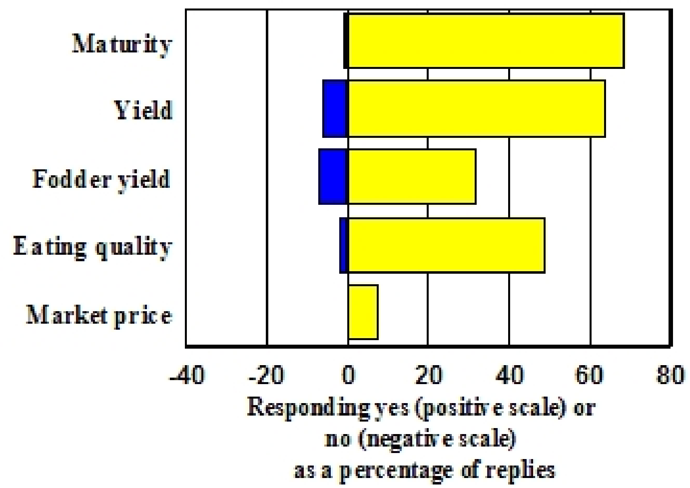

Fig.3. Summary of farmers' perceptions for GM-6 maize variety relative to the local checks

Effect on livelihoods: Farmers reported considerable impacts on their livelihoods with seed sales in maize increasing by 51% and food self-sufficiency by more than one month. Over 70% of the farmers growing the new maize varieties reported an overall increase of more than 10% in their total income (Table 7).

Table 7. Farmers' perceptions on the impact of the new maize varieties on their livelihoods.

Seed sales (t)		Food self sufficiency (months)		Impact on livelihoods (% total income)					
Before	After	Before	After	0 (no & %)	>0-10 (no & %)	10-20 (no & %)	20-30 (no & %)	30-40 (no & %)	>40 (no & %)
34	52 +51%	10.0	11.3 +13%	0 0%	27 24%	41 47%	4 26%	1 <1%	14 12%

Similar surveys were not conducted in eastern India but the informal PRAs and focus group discussions during on-farm trials revealed similar livelihood impacts of maize varieties. Farmers trade-off many traits while adopting new varieties. The earlier maturity of new varieties developed by COB increased options of farmers in adjusting their cropping patterns.

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? ***(max 300 words)***

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

Direct and indirect benefits:

- The wide scale adoption of the COB process will reduce national wastage associated with the breeding and testing of varieties that farmers would ultimately reject.
- Increased productivity per unit area without the use of additional external inputs especially pesticides is environmentally beneficial. The new varieties use nitrogen more efficiently so they reduce the demands for inorganic N that is an important pollutant and its synthetic production is a significant contributor to global warming.
- Increased productivity will reduce the pressure to increase the area under cultivation (Evenson and Gollin, 2003).
- Varietal diversification will help reduce crop loss due to pests and diseases and thereby reduce the use of pesticides. Introduction of new varieties has always increased on-farm diversity.
- The better disease and pest resistance of the new varieties can reduce the use of water and soil polluting agro-chemicals. Reduced use of pesticides and insecticides will also reduce the risk to human life and will help in creation of a balanced pest-predator cycle.
- GM-6 is highly suited to intercropping with horsegram is an ideal crop for reducing soil erosion. It covers bare soil when intercropped with maize.

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? ***(max 100 words)***

Any adverse environmental impact is unlikely in the present case as the new varieties are scale neutral and do not require any special cultural, management and production input.

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? ***(max 200 words)***

Earlier maturing varieties have increased the resilience of farmers by making the crop less prone to end-of-season droughts. Varietal and crop diversification is a means of coping with climate change. Intercropping of horsegram with maize is a highly resilient system as it spreads the risk between two crops.

If COB increases the number of varieties in a farmers’ portfolio then this can reduce risk and increase options within the farming system.

Annex

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