Improved maize fits niches in Indian and Nepalese hill farms

RIU

Validated RNRRS Output.

Farmers involved in testing improved varieties can be quick to see and take up possibilities. Hill farmers in India and Nepal given improved maize quickly chose those that fitted into empty niches in their traditional farming systems. In western India they chose maize suited for intercropping with horsegram. And in Nepal, subsistence farmers took the new varieties and intercropped them with finger millet in terraced agroforestry systems. Previously, farmers could do little with obsolete varieties—between 11 and 27 years old—that gave poor yields and didn't fit their farming systems. Now, nearly all farmers who have access to seed of improved maize choose to use them to boost production of food and fodder in various ways. The seed is also spreading through self-help groups and from farmer to farmer.

Project Ref: **PSP09:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **CAZS-NR, UK**
Source: **Plant Sciences Programme**

Document Contents:

Description

Research into Use
NR International
Park House
Bradbourne Lane
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UK

Geographical regions included:

India, Nepal,

Target Audiences for this content:

Crop farmers,

PSP09

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.

Participatory varietal selection in maize - improved varieties for India (JVM 421) and the mid-hills of Nepal (Manakamana 3)

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

Plant Sciences Research Programme

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.

R7281, Programme Development

UK
University of Wales, Bangor:
CAZS Natural Resources: Prof J.R. Witcombe, Dr D.S. Virk
School of Environmental and Natural Resources: Dr F.L. Sinclair

Western India
Gramin Vikas Trust (GVT), West:
Mr K.S. Sandhu (Project Manager) and Dr J.P. Yadavendra (Plant Breeder)
Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Indore:
Dr M. Billore

Nepal
Nepal Agricultural Research Council, Pakhribas:
Dr T.P. Tiwari

*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.*

Maize varieties identified through **participatory varietal selection** (PVS) for western India and mid-hills of Nepal. These are **JVM 421** variety for **western India** and **Manakamana 3** for the **mid-hills** of **Nepal** (Table 1).

Both of these **open-pollinated varieties** were introductions from the International Maize and Wheat Improvement Centre (CIMMYT). Variety JVM 421 is a derivative of ZM 421 from CIMMYT Zimbabwe and Manakamana 3 is from Population 22 of CIMMYT, Mexico. These varieties were given to farmers for testing because they had traits that farmers had specified as desirable.

Table 1. Description of maize varieties identified by PVS in India and Nepal

Details	Special features
Variety JVM 421 Released in 2006 in MP Suitable for MP, Rajasthan and Gujarat PVS trials 2002-2005	Medium maturity (100 d); lodging tolerance; cobs fully covered by husk; white-bold and flint grains with good cooking quality and taste; 100-seed weight 24 g; high protein content of 14% compared to 10% of JM-8 check variety; fairly tolerant to adverse conditions and poor fertility; responds to fertilisers; suitable for growing in rainy and post-rainy seasons.
Manakamana 3 Released in 2002 for mid-hills of eastern, central and western regions (1000 to 1700 m altitude) of Nepal PVS trials 1999 to 2000	High yield; late maturity (142 d); tall plants (2.3 m), prolific with 1 to 2 ears per plant; tolerant to lodging and *turcicum* blight; stay green type and shade tolerant; does well under drought and high input areas.

Maize is the most important crop of the hill districts of western Indian Gujarat, Rajasthan and Banswara. Surveys conducted by GVT showed that the adoption of improved cultivars of the major crops including maize was extremely low (Joshi and Witcombe, 1995; Witcombe et al., 2003). Similarly, maize is by far the most important cereal in the subsistence agriculture of the middle hills of Nepal (Tiwari, 2001). Both in India and Nepal, farmers largely grew old and obsolete varieties that gave low yields. In India, Witcombe et al. (1998) found that the average age of maize varieties was 27 years in MP, 20 years in Gujarat and 11 years in Rajasthan.

In Nepal, Population 22 was tested in formal coordinated trials from 1995 to 1999 but was not released because of its late maturity. When tested in PVS trials it was found to be the most preferred by farmers of the mid-hills who intercropped maize/finger millet in terraces that had trees on the margins (Tiwari, 2001). This demonstrated the value of involving farmers by using PVS.

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 the maize grown in the semi-arid tropics in India and semi-arid rainfed mid-hill farming systems of Nepal.

The maize variety in India is better for intercropping with legumes such as horsegram (PSP dossier 8 on intercropping of maize with improved horsegram; and PSP dossier 14 on improved horsegram better adapted to intercropping).

The maize variety in Nepal is better for cropping where there are multipurpose trees on the terrace bunds that shade the crop.

The process of participatory varietal selection can be applied to all major crops (see PSP dossiers 1 to 12 and 33).

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		*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 dossiers 1 and 35) where the maize varieties can be followed by the cultivation of pulses. It can combine with the seed priming (PSP dossiers 28 and 30).

The maize variety in India is more suitable for intercropping with horsegram (PSP dossiers 8 and 14). The maize variety in Nepal can be combined with Agroforestry systems where multipurpose trees are grown on terrace bunds and with improved finger millet.

Since farmers evaluate varieties for all traits including fodder quantity and quality then clustering with improved livestock nutrition would be synergistic.

In PVS, the new intervention is a crop variety which can combined with the testing of other interventions that are synergistic with new crop varieties, i.e., crop protection and improved crop agronomy interventions.

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)**.*

In PVS, validation is always by the first of the end users of a new variety – farmers - in on-farm participatory trials with participatory evaluation using a mother and baby trial design (Witcombe 2002). With Nepal as an example, the mother trials involved matrix ranking for many traits by farmers in focus group discussions (FGDs) at about 80 days after sowing, approaching harvest, and 3-4 months post-harvest. Focus groups of 5-8 farmers (male and female) ranked the varieties for each trait separately and overall. In post-harvest FGDs, farmers evaluated characteristics such as shelling percent, grit to flour ratio, taste, susceptibility to stored grain pests and market value.

The trials were replicated to provide tests of statistical significance. The on-farm trials and on-station trials were done by many organisations (Table 2 and see Question 12).

Additional on-farm validation involved informal research and development (IRD) where many farmers were given

a small quantity of seed for growing alongside their local control without collection of formal data.

The new varieties yielded much more grain than the local varieties (up to 52%) in both research station and on-farm trials (Tables 3 and 4) and they also excelled for other traits (Table 5).

Table 2. How the varieties were tested from 1995 to 2005

Year tested	Where tested/ Type of trial	Number of trials
JVM 421		
2002 to 04	On-station, Jhabua, MP	3
2003, 2004	State trials at 3 sites, MP	6
2005	Zonal trial, MP	1
2002 to 2004	Mother trials, MP	25
2002, 2003	Baby trials, MP	50
2002	On-farm trials, Guj by GVT	19
2003	On-farm trials, Guj, Raj by GVT	13
2003	Mother trials, Raj	4
2005	Mother trials, Raj	10
2003 to 2005	On-station trials, Guj	4
2003 to 2005	Mother trials, Guj	33
Manakamana 3		
1995 to 99	On-station Trials (CVT, Coordinated)	18
1998 to 00	FFT (Farmer field trials)	11
1999 to 01	Mother trials	13
1999 to 00	Baby trials	30

Table 3. Grain yield of JVM 421 in trials in MP, 2002-2005

Trial type and location	Year	Increase over GM-6 (%)	Increase over JM-8 or [check] (%)	Increase over local variety or [check] (%)
Mother trials, KVK, Jhabua	2002 to 2004	12	17	22
Mother trials, Jhabua district	2002 to 2004	17	22	29
State Varietal Trial - Indore, Dhar, Jhabua	2003, 2004	11	19 [JM-1]	-
Baby Trials, Jhabua	2002, 2003	-	-	24
Zonal trial - KVK Chhindwara	2005	-	27	-
Mother trials, Raj	2003			29
Mother trials, Raj	2005			17
Research trials, Guj	2003 to 2005			19 [N. Moti]
Mother trials, Guj	2003 to 2005			17 [GM-4]

Table 4. Yield increase of Manakamana 3 over local in various trials

Trials and location	When (year)	Increase over local (%)
On-station trials (CVT, Coordinated) by six Agricultural Research Stations (ARS)	1995 to 99	10
FFT (Farmer field trials) by two ARS	1998 to 00	52
Mother trials, Pakhribas villages	1999 to 01	38
Baby trials, Pakhribas villages	1999 to 00	21

Table 5. Some of the additional important traits of the new varieties

Variety	Special traits
JVM 421	Early maturing; white, bold, good quality grains with better cooking quality and taste; high yield potential with tolerance to leaf diseases; good quality fodder.
Manakamana-3	Suitable for finger millet intercropping; shade tolerant, suitable for maize-millet and tree inter-phase; stay green trait provides good quality fodder after grain maturity.

*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)**.*

India

The outputs were tested in the semi-arid, smallholder, rainfed system from 2002 to 2005. The testing was carried out under rainfed conditions.

It was centred on Jhabua district MP but the variety was also tested in adjoining areas of eastern Gujarat and southern Rajasthan. The districts were Jhabua (MP), Panchmahals (Gujarat) and Banswara (Rajasthan). These are hilly areas populated by indigenous peoples who are very resource-poor and farm small and fragmented landholdings. 65% of households live below the poverty line. Maize is the main rainy season (*kharif*) crop and is grown in low-fertility fields, often on sloping land that is vulnerable to soil erosion. Maize productivity is very low, averaging below 1 t ha^{-1}.

Nepal

The outputs were tested in the semi-arid, hillside, smallholder, rainfed system from 1998 to 2000.

About 80% of the maize in Nepal is grown in the hills under diverse agro-ecological conditions. The hill agriculture is largely for subsistence. Typically, a single farm is four to five pieces of land scattered across more than one agroecological zone. Hill maize is grown in a range of cropping systems in the mid hills; maize with finger millet followed by fallow or by toria or maize followed by toria. In all rotations, trees are an important part of the arable landscape and they shade the maize terraces. Indigenous, resource poor farmers of Marga, Fuchchamara and Patle villages in the eastern mid-hills were involved in the PVS studies. They grow maize-millet intercrops in terraces having trees on the edges. Subsequently the variety was tested in a wider area of eastern Nepal.

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 both India and Nepal farmers do not have to change how they grow these maize varieties as they do not require any special cultivation practices. The users are male and female farmers who are from all social groups representing resource-rich, resource-medium and poor farmers.

In western India, farmers use JVM 421 as one component of the maize farming system. It is of longer duration than other varieties such as GM-6 so it is preferentially grown on the better soils in the lower lands. Consequently it does not occupy a very large proportion of any individual farmer's land but will make a disproportionately large contribution to total maize production. It is grown for grain, for home consumption and for sales, and for its high quality stover. Some of the grain will be kept for resowing.

In Nepal, farmers of these complex hillside farming systems needed more varieties to fit all of the niches and to satisfy their multiple needs for grain and fodder. Manakamana-3 was tested in the formal trials system of Nepal from 1995 to 1999 but was not identified for release because of its late maturity. However, evaluation by farmers in PVS trials from 1999 to 2001 revealed that farmers did not perceive late maturity to be a problem as there is no possibility of a following crop in the same year. They traded off any possible disadvantages of the late maturity of Manakamana-3 against its higher grain yield, shade tolerance and other useful traits.

*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).***

The outputs are being used in the rainfed semi-arid agricultural system in India and Nepal.

The outputs are being used in India in the three western states of MP, Rajasthan and Gujarat in the better lands of the hilly districts of Jhabua and Ratlam (MP), Panchmahals (Guj) and Banswara (Rajasthan). It is certain that JVM 421 is adapted to maize growing areas outside of these districts and likely that seed has been distributed there but no assessments have been made.

In Nepal Manakamana 1, is released for the mid-hills of the eastern, central and western regions at 1000 to 1700 m altitude. Following dissemination programmes, is now being used by hill farmers in more than 20 districts of Nepal.

*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 the current use can be extrapolated from the scale of promotion activities. Participatory assessments show that both JVM 421 and Manakamana-3 are adopted by most (90% or more) of the farmers that have access to seed. The amount of seed that has been distributed is large and it has been to many farmers. Given that farmers also distribute seed of these varieties once they have sufficient for resowing for themselves the spread is larger than the seed supply. The complicating factor in describing the usage is that as an open-pollinated variety is grown from year to year it is progressively less pure because of cross-pollination to other varieties.

The scale of the promotion (as an indicator of usage) is described here for JVM-2 and for Manakamana-1 in Question 16.

India
Seed production was undertaken by JNKVV and GVT from 2002 to 2006. JNKVV produced seed on the research farm and GVT the self-help groups of farmers (Table 6). By 2006, the total coverage by JVM 421 from seed distributed by GVT and JNKVV was sufficient for about 400 ha. Over 100 farmers had received seed directly from the two institutions in Gujarat, Rajasthan and MP but many more farmers would have received seed in the farmer-to-farmer distribution.

Further seed production is being undertaken in the rainy season of 2006 sufficient for sowing a further 200 ha.

Table 6. Quantity of seed of new variety JVM 421 by GVT west to GOs, NGOs and farmers

Year	State	Quantity (kg)	Sufficient to sow (ha)
2002	Guj	921	37
2003	MP	100	4
	Guj	1085	43
2004	Raj	80	3
	Guj	100	4
2006	MP	2000	80
	Guj	450	18
	Total	4736	189

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).***

Western India: 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 should 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. Hence, 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, Community Resource Centres under District Rural Development Agency. Also some NGOs such Action for Social Advancement (ASA),

PRYAS, SAMARTHAN. They have collaborated with GVT in supplying seed of maize varieties.

Nepal. The dissemination of Manakamana 3 has been done through the Nepal Agricultural Research Council (NARC) Agricultural Research Stations such as Pakhribas, Kabre, Dailekh and Lumle; through the National Maize Research Programme, Rampur; the Hill Maize Research Programme (HMRP), CIMMYT, Kathmandu; the District Agriculture and Development Offices (DADOs); and partner NGOs such as TUKI Association, Sindhupalchwok, LI-BIRD, FORWARD, CEPRED, TTRI, ABTRACO, CAERD, DOS-Gorkha. Of these the HMRP is perhaps the most important and has provided a platform to spread the variety to more than 20 districts in the mid-hills and have an influence in promoting community-based seed production (CBSP).

Policy: In India, the seed production of maize varieties takes place on the basis of assured, written orders (indents). Unless there is an indent for seed GOs will not produce it. This applies rigorously for breeder seed and to a lesser extent for certified or truthful seed. Seed production of JVM 421 has been limited because indents have not been received from the department of agriculture in the state who, in turn, are not fully aware of the variety. Thus there is an inadequate linkage. Although the situation is similar in Nepal there is a closer linkage between the District Agricultural Development Officers with farmers and then with NARC that provides a better assessment of demand. How well the demand is translated into demand will vary.

Capacity strengthening: To promote adoption of new varieties to any significant level improved capacity in the following areas are required:

- Large-scale seed production and distribution.
- Awareness raising with stakeholders of the new varieties through meetings, demonstrations and availability of appropriate literature.
- Training in community-based seed production.
- Involvement of private-sector seed companies.

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).***

India
The scale of current use is related to scale of promotion and this was described for India in Question 14. In addition, promotion is taking place in organisations associated with JNKVV and GVT. These include the Madhya Pradesh Rural Livelihoods Project (MPRLP) and the Poverty Initiative Programmes (DPIP), the National Watershed Programme and Community Resource Centres under the District Rural Development Agency. Also, NGOs such as the Action for Social Advancement (ASA), PRYAS and SAMARTHAN.

Nepal

Maize seed has been distributed in eastern, central, western, mid-western and far-western development regions of Nepal in 2004 and 2005. Seed kits were supplied on a large scale to 9,500 farmers (Table 7) of which 24% were women farmers in both 2004 and 2005. Over 90% of the farmers saved the seed of this new white-grained variety.

Seed production of Manakamana 3 has been undertaken by several GO and NGOs. Along with Breeder and Foundation seed production the community-based seed production (CBSP) produced certified seed. The seed distributed to farmers was sufficient to sow 4200 ha and covered about 42,000 households (Table 8).

Depending on the year 30 - 100 farmers across locations are engaged in CBSP, every year. They sell maize seed on double price of grain, i.e., NRs 20 per kg.

Table 7. Number of seed sets given in Farmers' Acceptance Test (FATs) through hill DADOs in 2004 and 2005.

Year	EDR†	CDR‡	WDR§	MWDR	FWDR#	Total
2004	350	600	200	1280	1120	3550
2005	800	1200	1500	3200	2800	9500

† EDR= Eastern Development Region.
‡ CDR= Central Development Region.
§ WDR= Western Development Region.
¶ MWDR= Mid Western Development Region.
# FWDR= Far Western Development Region.

Table 8. Seed production of Manakamana 3, 2002 to 2006

Years	BS	FS	CBSP	Area covered§ (ha)	Households†
2002	140	3170	6000	200	2000
2003	70	1670	40900	1363	14000
2004	120	1380	22700	757	8000
2005	40	1463	71245	2375	24000
2006*	200	3400	125000	4167	42000

BS = Breeder seed; FS = Foundation seed; CBSP = Community based seed production;
§Caculated using farmers' seed rate of 30 kg ha^{-1} but the national recommendation is 20 kg ha^{-1}.
†To nearest thousand. In the hills the maize area of each households is about 5 Ropanies. The number of households assumes that an average farmer grows Manakamana 3 on at least 2 Ropanies.
* Estimated.

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)****.*

A barrier is a lack of a sustainable seed supply system for open-pollinated varieties of maize in India and Nepal.

In Nepal such a system faces even greater challenges because the mid-hill regions are remote and the terrain does not allow large weight and volume of seed to be economically transported over even relatively short distance.

The public sector, particularly in India, has suffered from the vicious circle of a lack of demand resulting in lack of seed production resulting in lack of demand because demand can only come if farmers have seen the variety. The process has to start with extension by the departments of Agriculture who demand seed for this process. However, there is a disconnect between extension and research.

One possibility is an increased role for the private sector. However, for the formal private sector there is the problem that investment in more favourable agricultural areas (irrigated areas in India and the *terai* in Nepal) and hybrid seeds.

The other private sector is the farmers themselves. In India, working in a poverty-focused approach by establishing groups within villages has been fraught with problems caused mainly by the low and erratic productivity that varies with the rains along with poor access to markets. In India, there is a need to establishing groups in more favourable areas that are not too remote from the target areas and where emphasis is placed on training in commercial matters relating to the seed business. In Nepal, erratic production (and erratic demand) is less of a problem as the rainfall is higher but the need for decentralisation is far greater because of difficulties of transportation. However, the motivation to produce quality seed of the staple crop maize is probably higher and mountain communities in Nepal are used to cooperative efforts in, for example, the management of community forests.

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 changes vary with the situation. In India awareness raising to create demand is the most important, while in Nepal it is approaches to community –based seed production. In India, awareness needs to be raised at all levels (State Agricultural Universities, NGOs, Departments of Agriculture and the private sector) about the JVM 2 (and other new maize varieties such as GM-6). Generally the awareness of new varieties takes a long time to reach the stakeholders.

In both India and Nepal steps have been taken to try and produce seed on the scale that is demanded. Lessons need to be learnt from these experiences (such as, in India, not attempting to have a poverty-focused approach to seed production in poor villages where seed cannot reliably be produced in drought years). Such lessons have to be applied but also modifications need to be tested to add to these lessons (see PSP dossier 36). Suitable modifications, when soundly based on lessons from current initiatives, could add great value. All this requires a fundamental change in seed-production based development by placing as much emphasis on monitoring and evaluation for lesson learning as for the seed production itself. This has proved to be difficult as development-oriented NGOs are more concerned with the results than the process.

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 maize varieties and landraces produces great increases in grain yield.

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 their traditional farming systems. The process of PVS has a low compatibility with the traditional linear process of research to extension.

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 maize varieties does not entail any change in farmers' practice. The process of PVS is more complex for researchers and extensionists.

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 grow new variety alongside their own variety without changing the management.

Hence, the provision of a sustainable seed supply and the changing of mindsets of researchers and extensionists are the most important factors 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.

Very little impact assessment has been done, so far, on these varieties. There is some information on the impact of ZM 421 (JVM 421) in the publication below.

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.

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*

The target farmers were the indigenous, resource-poor farmers who benefited the most from the adoption of these PVS varieties.

Farmers' perceptions for JVM 421 in India showed that significantly more farmers preferred it for higher grain yield, higher fodder yield and good eating quality (Fig. 1) over the local variety. The farmers' local check varied from place to place and more farmers perceived JVM 421 to be later maturing. The 20% who felt it to be earlier maturing were probably comparing it to a very late maturing local variety.

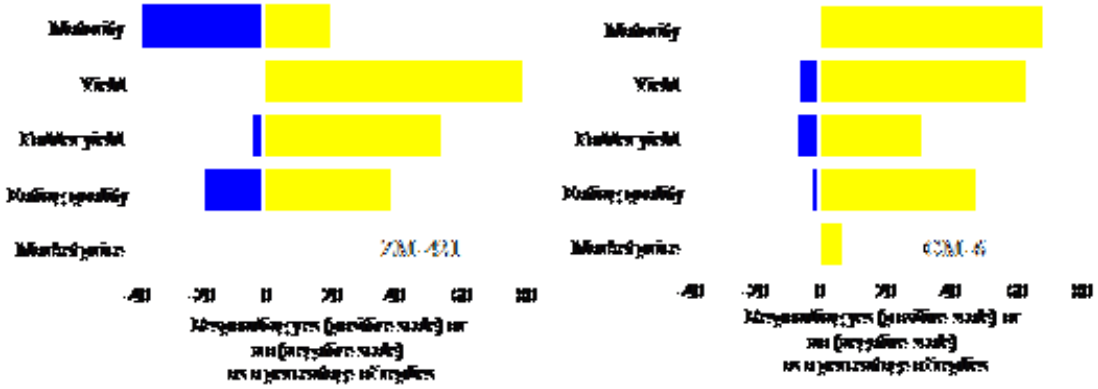

Fig. 1. Farmers' perceptions for JVM 421 relative to the local checks in Western India - MP, Raj and Guj (left). It can be compared to GM-6 (right). ZM-421 can be seen to have a higher grain and fodder yield than GM-6 and to be a later-maturing option that is more adapted to better fields.

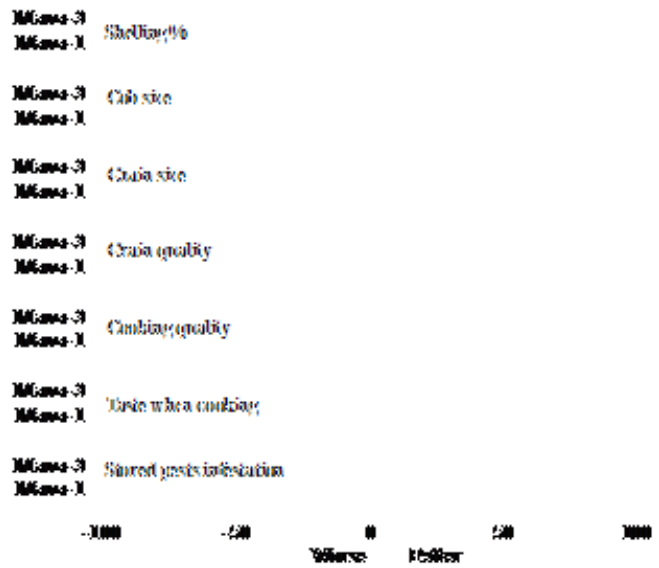

Fig. 2. Farmers' perceptions of Manakamana 3 compared with Manakamana at the post-harvest stage (mean over 1999 and 2000) traits. Farmers' perceptions as to whether the test varieties were better or worse than the local variety are indicated by lines in percent. The shorter the line, the more similar the variety is to the local variety.

In focus group discussions male and female farmers were in a good agreement to rank Manakamana-3 as first over years and locations in Nepal. At the pre-harvest stage farmers liked Manakamana-3 for its shade-tolerance, longer ears, taller plants, lodging resistance, stay-green characteristic and better fodder quality, and resistance to foliar diseases particularly turcicum blight. At the post-harvest stage Manakamana-3 was rated better for shelling per cent, cob size, grain size and quality, cooking quality and lower susceptibility to stored grain pests (Fig. 2).

The impact of Manakamana 3 on the livelihoods of farmers is yet to be documented. However, farmers report that the yield benefit from Manakamana 3 is between 20-50% over the local variety depending on location. Farmers perceived that food availability had increased from 3 months to 4-5 months with the adoption of Manakamana-3.

The yield gains from the new varieties showed that the participating farmers benefited from the new varieties given in PVS. The most important aspect is the better performance of new varieties in rainfed conditions of farmer fields where these varieties were more drought tolerant. Substantial increase in yield and fodder for the rainfed and small holders has great implications on the livelihoods of poor people.

The increased yields reduced poverty and increased food security and purchasing power of the participating farmers who had improved their living standards by using additional incomes from increased yields.

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:

- Increased productivity per unit area without the use of additional external inputs is environmentally beneficial. This could be achieved by growing farmer-preferred varieties without changes in management.
- More than one variety is promoted and found to be preferred by farmers will increase on-farm diversity and help reduce crop loss due to pests and diseases and thereby reduce the use of pesticides.
- In India, earlier maturing maize varieties will promote cultivation of rainfed *rabi* crops such as chickpea to improve soil fertility.
- The better disease and pest resistance of the new varieties means a lesser use of water polluting agro-chemicals and reduction in soil pollutants. Reduced use pesticides and insecticides also reduced risk to human life and helped in creation of balanced pest-predator cycle and regeneration of micro-eco-system.
- The higher fodder yields of the new varieties would reduce deforestation for wood and fodder.

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)***

Varietal diversification is a means of coping with climate change because staggered deployment of varieties with different dates of maturity spreads out water demands and reduces the risks from natural disasters such as diseases and pests and natural calamities. This is particularly true for western India with the deployment of GM-6 and JVM 421 varieties that have different times to maturity.

The new maize varieties do well under droughted conditions but also respond to better conditions. This increases the capability of farmers to cope with natural risks.

If PVS increases the number of varieties in a farmers' portfolio then this can reduce risk and increase options. New variety in India allows the intercrop of legumes that increases the overall profitability and creates more options for the farmers. In Nepal, new variety allows maize-millet intercrop along with trees on terraces that

increases farmers' resilience due to better performance in shade.

Annex

References

Joshi, A. & Witcombe, J.R. (1995). Farmer participatory research for the selection of rainfed rice cultivars. In: Proceedings of the International Rice Research Conference, 13-17 Feb, 1995. Fragile Lives in Fragile Ecosystems. IRRI. pp. 825-842.

Tiwari, T.P. 2001. Participatory crop improvement for maize/millet intercropping with trees in the middle hills of Nepal. PhD thesis, School of Agricultural and Forestry Sciences, University of Wales, Bangor, UK.
Witcombe, J.R., Packwood, A.J., Raj, A.G.B. & Virk, D.S. 1998. The extent and rate of adoption of modern cultivars in India. pp. 53-68 in Seeds of Choice. Making the most of new varieties for small farmers. J.R. Witcombe, D.S. Virk and J. Farrington (Eds). Published by Oxford IBH, New Delhi and Intermediate Technology Publications, London.

Witcombe, JR. 2002. A Mother and Baby trial system. in: Breeding rainfed rice for drought-prone environments: integrating conventional and participatory plant breeding in South and Southeast Asia. Proceedings of a DFID Plant Sciences Research Programme/IRRI Conference,, 12-15 March 2002, IRRI, Los Ba•os, Laguna, Philippines. Department for International Development (DFID) Plant Sciences Research Programme, Centre for Arid Zone Studies (CAZS) and International Rice Research Institute (IRRI), Bangor and Manila. Appendix, 79.

Witcombe, J.R., Joshi, A. & Goyal, S.N. 2003. Participatory plant breeding in maize: A case study from Gujarat, India. Euphytica 130:413-422.