Farmers now benefit from better sorghum varieties

Validated RNRRS Output.

Over three years in India, farmers tested 27 varieties of sorghum in their fields. They chose five, and three of these went on to be officially released. All three are resistant to shoot fly and charcoal rot and make good roti flour. Plus they are suitable for intercropping with chickpea or safflower. Until these trials, farmers weren't benefiting from decades of plant breeding because researchers had just concentrated on raising yields. They had overlooked strains that made good roti flour although this was an important factor for farmers. So, farmers didn't adopt the new varieties. On-farm trials meant that farmers, as well as testing new varieties could, at the same time, try out better farming practices such as transplanting seedlings rather than sowing seed directly.

Project Ref: **PSP05:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **CAZS-NR, UK**
Source: **Plant Sciences Programme**

Document Contents:

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Geographical regions included:

India,

Target Audiences for this content:

Crop farmers,

Description

PSP05

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 *rabi* sorghum – improved varieties Phule Yashoda, Mauli and Parbhani Moti for India.

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

PSP

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.

R7409

Partner institutions and individual persons:

- CAZS-Natural Resources, UK: Dr D.S. Virk and Prof. J.R. Witcombe
- Directorate National Research Centre for Sorghum (NRCS), Hyderabad: Dr B.S. Rana, Dr (Mrs) S.L. Kaul, Dr Appaji Chari,
- ICRISAT, Patancheru, AP: Dr Belum S. Reddy

Organisation	Maharashtra
Agricultural Research Station	· Mahatama Phule Krishi Vishav Vidayalaya, Rahuri, Maharashtra: Dr B.N. Narkhede · Maharashtra Agricultural University (MAU), Parbhani, Maharashtra: Dr S.T. Borikar · Centre on Rabi Sorghum, Solapur, Maharashtra: Dr Prabhakar, · Krishi Vigyan Kendra (KVK), Agricultural Research Station, Dhule
NGO	· KVK, Jeevan Jyothi Charitable Trust, Parbhani · KVK, Shri Siddeshwar, Krishi Vigyan Prasarak Samstha, Solapur, Maharashtra. · Maharishi Vivekanand Samaj Kalyan Santhan, Akkalkot, Maharashtra.
	Karnataka
Agricultural Research Station	· University of Agricultural Sciences, Main Sorghum Research Station, Dharwad, Karnataka: Dr N.Y. Nayakar · Agricultural Research Station, UAS, Bijapur, Karnataka: Dr B.D. Biradar and Dr M.S. Patil
NGO	· Institute for Studies on Agriculture and Rural Development (ISARD), Dharwad, Karnataka. · Association for Studies on Agricultural and Rural Development (ASEARD), Bijapur, Karnataka.
	Andhra Pradesh
NGO	· Deccan Development Society, Hyderabad · Centre for Environment And Development (CESC), Secunderabad, Andhra Pradesh (AP)

*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.*

The outputs are three *rabi* sorghum varieties, **Phule Yashoda, Mauli** and **Parbhani Moti** (Table 1), for **rainfed** conditions. All are tolerant to **shoot fly** and **charcoal rot** and have **semi-compact** panicles. Parbhani Moti and Phule Yashoda have **excellent cooking quality** with good *roti* quality. These varieties are suitable for **intercropping** with chickpea or safflower.

Table 1. Description of outputs

Variety	Adaptation	When released and where	Special features
Phule Yashoda (CSV-216R or SPV -1359)	Medium to deep soils in Maharashtra, Karnataka and AP	2000 All India	Selection from Dhulia non-tan germplasm; round bold pearly white grains.
Parbhani Moti (SPV-1411)	Medium to deep soils in Maharashtra	2003 Maharashtra	Selection from non-tan germplasm; bold pearly white lustrous grains.
Mauli (RSLG-262)	Shallow to medium soils in Maharashtra	2002 Maharashtra	Selection from a non-tan landrace; bold pearly white lustrous grains.

All the varieties were tested in PVS trials and released during the project period from 1999 to 2002.

Growers of *rabi* sorghum in the project states did not have any alternative to the popular but very old local varieties Maldandi and M35-1, a selection from Maldandi. Maldandi was released in 1930 in Maharashtra and M35-1 was released for Maharashtra, Karnataka and AP in 1984. This low genetic diversity made the *rabi* sorghum crop potentially highly vulnerable to diseases. It also meant that farmers were not benefiting from decades of plant breeding research as new varieties that had been released were not adopted by them largely because plant breeders had concentrated on yield rather than providing varieties that at least matched M35-1 for grain quality (Witcombe *et al.,* 1998).

The PVS approach removed the major limitation of the public sector breeding programme by selecting varieties in the farmers' fields under their own management, and so minimised genotype x environment interaction resulting from the high input and management conditions on research stations. In three years, farmers were provided 27 varieties to test and choose from. They preferred five of them, of which three were subsequently released.

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 *rabi* sorghum suitable for shallow, medium and deep soils in Andhra Pradesh (AP), Karnataka and Maharashtra states in India under rainfed conditions. The rabi sorghum follows a wide range of rainy season crops such as groundnut, pearl millet, maize and sorghum. Therefore the improved varieties of rabi sorghum are relevant to these commodities in a farming systems.

The PVS process can be applied to all crops (see PSP dossier 33 on the PVS process).

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 *rabi* sorghum by PVS is an intervention which can be combined with the testing of other interventions that are synergistic, for example crop protection and improved crop agronomy interventions such as transplanting (PSP dossier 31). The output can be linked with the rainfed *rabi* fallow projects (PSP dossier 35), seed priming (PSP dossier 27) and intercropping with chickpea using seed priming in the rainfed *rabi* fallows (PSP dossier 26). Since farmers evaluate varieties for all traits including fodder quantity and quality then clustering with improved livestock nutrition would be synergistic.

It fits well with participatory varietal selection (PSP dossier 33), COB (PSP dossier 34) and community-based seed production (PSP dossier 36).

It is also synergistic with outputs that improve the preceding crop such as groundnut and also with others:

NRSP, Participatory Technology Development, R7412
NRSP, Scaling-up process, R7865
CPP, Linking demand with supply of agricultural information, R8429, R8281
CPP, Good seed initiative, R8480
CPP, Increasing effectiveness of research system, R8410
CPP, Rosette resistant groundnut varieties, R7445, R6811
CPP, Commercial incentives for groundnut production and farmer led multiplication, R8422, R8105
CPP, Farmer multiplication systems (groundnut/potato), R8104, R8435

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)**.*

How validated: Participatory varietal selection (PVS) methods were used. A baseline survey was conducted to discover farmers' current varieties and their preferences, and showed that most farmers primarily grew a very old variety M35-1. New varieties for the farmers to test were selected from those in initial and advanced all-India Coordinated trials and from ICRISAT that fitted the farmers' criteria. The market price of sorghum varieties is generally based on grain size, grain colour/lustre and whether the variety was a composite or a hybrid. Farmers wanted a variety that would sell well in the market.

Participatory trials were conducted by farmers who were provided 1 or 2 kg seed of each new variety. The on-farm trials were conducted on 27 varieties from 1999-00 to 2001-02. These trials were baby trials, where a new variety was grown alongside the local check, or mother trials, where all entries were grown together in a single replicate by a farmer (Witcombe, 2002). Farmers served as replications. All trials were conducted under the farmer's normal management. The on-farm trials were conducted by the six centres of the All India Coordinated Sorghum Improvement Project (AICSIP) located at the NRCS, the State Agricultural Universities in Maharashtra and Karnataka and at ICRISAT with the help of seven NGOs. A total of 720, 838 and 1,026 on-farm trials were conducted in 1999-00, 2000-01 and 2001-02 respectively, and were jointly monitored by researchers and farmers. Both pre-and post-harvest traits were evaluated by both participating and non-participating farmers.

Table 2. Number of research trials for validation, and number of farmers who validated the products from 1999-00 to 2001-02

Variety	When (years)	Where (states)	No. of Res. Trials	No. of AICSIP trials	No. of PVS trials	No. of NGOs involved
Phule Yashoda	1999 to 2002	AP, Maharashtra, Karnataka	12	24	585	6
Mauli	1999 to 2002	AP, Maharashtra, Karnataka	12	24	196	6
Parbhani Moti	1999 to 2002	AP, Maharashtra, Karnataka	12	24	176	6

Who validated: Validation was done with the technical help of CAZS-NR and NRCS, India. The validation trials were conducted by NRCS and ICRISAT in AP; by the ICAR All India Coordinated Sorghum Improvement Project (AICSIP) located in State Agricultural Universities (SAUs) at Solapur, Rahuri and Parbhani in Maharashtra; and Dharwad and Bijapur in Karnataka. In addition seven non-governmental organizations (NGOs) were also involved in the three states. In Maharashtra these were the KVK, Agricultural Research Station, Dhule; KVK, Jeevan Jyothi Charitable Trust, Parbhani; the KVK, Shri Siddeshwar, Krishi Vigyan Prasarak Samstha, Solapur; and the Maharishi Vivekanand Samaj Kalyan Santhan, Solapur. In Karnataka, NGOs were the Institute for Studies on Agriculture and Rural Development (ISARD), Dharwad, and the Association for Studies on Agricultural and Rural Development (ASEARD), Bijapur, while in AP they were the Deccan Development Society, Hyderabad, and the Centre for Environment and Development (CESC), Secunderabad.

The target groups of male and female farmers were from all social groups representing resource-rich, medium and poor farmers. Wealth categories were determined through local informants using key proxies for wealth such as landholding size. The participating farmers included all social groups including the lower castes. Evaluation of PVS trials included participating farmers (with a representative proportion of women) and their neighbours, relatives and friends (this always included some women). The evaluation of the post-harvest traits always involved women.

Increases in productivity: M35-1 is the most popular variety of *rabi* sorghum, and was used as a check to compare new varieties. Overall, in trials between 1999-00 and 2001-02, the new varieties gave 19 to 47% more grain yield and 14 to 43% more fodder yield (Table 1). However, Mauli was lower yielding than M35-1 by 5% when trials in all types of soils were considered, although it yielded 20% more fodder. Mauli specifically performs better in shallow to medium soils where M35-1 does not perform well, with grain yields about 20% higher in such conditions. Despite the higher grain and fodder yield of the new varieties they had similar maturity to M35-1 (Table 2), while Mauli is three days earlier than M35-1, making it specifically adapted to shallow soils which are prone to terminal drought.

Table 3: Average grain and fodder yield of new varieties in comparison to M35-1 over three years across all locations from 1999-00 to 2001-02

Entry	No. of trials	Maturity (days)	Grain yield (t ha^{-1})	Increase over M35-1 (%)	Fodder yield (t ha^{-1})	Increase over M35-1 (%)
Phule Yashoda	585	125	1.58	25	3.99	26
Parbhani Moti	176	120	1.86	47	4.39	39
Mauli	196	117	1.21	-5 (20%)†	3.80	20
M35-1 (Check)	59	120	1.27	-	3.16	-

†The overall average is based on trials in all type of soils. However, the variety is released for shallow to medium soils where normally M35-1 does not perform well. It gives about 20% more yield than M35-1 in shallow soils.

In addition to higher yield, farmers recorded a number of other preferred traits in the new varieties (Table 4). The most important was the drought tolerance of Mauli under rainfed conditions in shallow soils with very poor water holding capacity.

All three varieties are suitable for intercropping with chickpea and safflower, which can add value to the output.

Table 4. Traits other than yield for which new varieties excel M35-1 (farmer perceptions)

Variety	Traits other than grain yield
P. Yashoda	Tall plants, bold grain with easy threshability, better flour recovery with good keeping quality of flour
P. Moti	Very bold and attractive lustrous grains which fetch a higher market price; fodder preferred by animals; very good roti quality
Mauli	Fodder preferred by cattle; tolerant to aphids and leaf sugary disease; tolerant to terminal drought.

*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 varieties were validated in three states in India: Maharashtra, Andhra Pradesh and Karnataka, where *rabi* sorghum is grown on 5.42 M ha out of a total area of 5.6 M ha. The outputs were validated from the 1999-00 to the 2001-02 seasons.

The validation locations were:

Andhra Pradesh: Medak (NRCS and ICRISAT)
Maharashtra : Solapur, Dhule (Rahuri centre), and Parbhani
Karnataka: Bijapur and Dharwad

Validation was done through seven NGOs who conducted trials in the following types of soil

Bijapur/Solapur: Shallow, medium, deep and irrigated
Dharwad: Medium, deep and irrigated
Parbhani: Medium, deep and irrigated
AP (Hyderabad): All types of soil except irrigated

All these sites have centres of the ICAR's AICSIP located in state agricultural universities (SAUs). Seven NGOs, six centres of the AICSIP located in SAUs, the National Research Centre for Sorghum (NRCS), and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) collaborated in the research (Table 2 and Q 3).

The outputs were validated by farmers in their fields under their own management and by researchers on the research stations. Hundreds of farmers, of all wealth categories, in the three states took part. However, a special focus was on evaluation by resource poor and women farmers.

The outputs were validated in the semi-arid system in small-holder in rainfed dry and humid systems. All testing was carried out under rainfed conditions.

Current Situation

C. Current situation

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

Farmers were given only 1 to 2 kg seed of any new variety for testing and adopting, and saved the seed of preferred varieties to continue growing them on a limited scale. Seed exchange among farmers has been slow. The outputs are on the recommended list of AICSIP, and the State Agricultural Universities in Maharashtra.

Farmer-to-farmer spread since 1999, when the project supplied the seed to farmers for testing in PVS, has undergone a number of multiplications and exchanges. Therefore there is a high chance of seed deterioration due to admixtures, and farmers' seed needs to be replaced immediately.

Usually there is a gap of 5 years between release and dissemination. All three varieties are from Maharashtra State, and a limited quantity of seed of the released varieties has been produced by the Agricultural Universities at Rahuri and Parbhani in Maharashtra. The Maharashtra State Seed Corporation (MSSC) has also produced some seed of all the varieties, which has met some of the demand from farmers in Maharashtra, but no seed has yet been made available to farmers in AP and Karnataka where Phule Yashoda is also recommended. Even in Maharashtra, seed supply to farmers of remote villages is constrained.

*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 products are being used in Andhra Pradesh, Maharashtra and Karnataka states in India by the farmers who participated in the PVS project. These varieties are recommended in these states, and have entered official seed channels.

These varieties are also grown in the areas of activity of the collaborating NGOs who conducted trials in various soil types (See Q 10).

Informal seed spread among farmers within the three states and in those adjoining has also encouraged their spread into other sorghum-growing areas of India where they are preferred by farmers.

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

The project operated from 1999 to 2002. Within these three years, three varieties were released that were preferred by farmers over existing material. This has generated a high seed demand, although no single agency can meet it. As seed production by the SAUs in Maharashtra and the Maharashtra State Seed Corporation (MSSC) is limited, the spread of the released varieties is largely limited to Maharashtra, and then only to areas near the universities.

About 30% of the participating farmers in all three states are continuing to cultivate these varieties from farm-saved seed.

Present status: Farmers in Maharashtra have benefited from seed supply within the state but those in Karnataka and AP do not have an assured seed supply and are constrained. Even with the all-India release of Phule Yashoda, no large scale seed production has yet taken place. The total amount of seed supplied by MSSC and the SAUs in 2005-06 for all varieties is sufficient to sow only about 29,000 ha in the 2006-07 *rabi* season (Tables 5 and 6).

Table 5. Detail of certified seed produced and disseminated by Maharashtra State Seed Corporation, Akola during 2005-06 *rabi* season and the amount of seed of three varieties distributed in PVS trials

Variety	When (Year)	Where (State)	Quantity produced by MSSC (t)	Quantity produced by SAUs (t)	Quantity distributed (t)	Quantity given in PVS trials from 1999-2002 (kg)	Estimated area (ha)
P. Yashoda	2005-06	MSSC, Akola	200	15	215	1176	21618
P. Moti	2005-06	MSSC, Akola	30	6	36	352	3633
Mauli	2005-06	MSSC, Akola	40	6	46	392	4639
Total			270	27	297	1920	29890

Table 6. Detail of breeder seed production

Variety	When (Year)	Where (State)	Quantity of seed produced (kg)
P. Yashoda	2005-06	MPKV Rahuri	100
P. Moti	2005-06	MPKV Rahuri	50
Mauli	2005-06	MPKV Rahuri	50

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).***

The NRCS and AICSP, ICRISAT and State Departments of Agriculture have assisted in the promotion and popularisation of these sorghum varieties through on-farm PVS trials, demonstrations, frontline demonstrations, minikits and adaptive trials. The Zonal Agricultural Research Stations of the State Agricultural Universities and the 7 associated NGOs also assisted in the dissemination activities by conducting on-farm trials.

Local level bodies such farmers' cooperatives and groups, self-help groups formed by NGOs, and village Panchayats have assisted in selecting farmers to validate the outputs.

In terms of capacity strengthening for testing PVS products and creating demand for seed of un-released varieties the key factors are:

- Raising of awareness about these new varieties (and the PVS technology) through existing networks.
- Capacity building by training to GOs, NGOs and farmer groups.
- Creating awareness with the stakeholders for the new varieties through workshops, demonstrations and publication of literature.

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).***

The current promotion is in Maharashtra State, India, where all three released varieties are recommended and two are released specifically for the state. This is conducted by the State Agricultural Universities and the Maharashtra State Seed Corporation, for the released varieties only. No promotion of varieties released by Maharashtra takes place in AP or Karnataka, although limited promotion of the all-India released variety, Phule Yashoda, is under way in all three states. This limited promotion is because of the gap of about five years between release and dissemination of a variety, due to the long chain from breeder to the production of certified seed. There is undoubtedly a high seed demand, but no single agency can meet it (see question 14).

Farmers of the three states where the project operated saved seed from the PVS trials, and many hundreds of these farmers are continuing to grow the new varieties. Seed has also spread to other farmers through informal seed channels. Enough seed to sow about 29,000 ha of the new varieties was produced by the MSSC in 2005-06, but this is very small compared to the total seed requirement for *rabi* sorghum.

NRCS promoted new sorghum varieties in all three states by popularising better ways to use grain. Although farmers' have accepted all these varieties, they needed education and training in improving flour recovery, *roti* quality and keeping quality for which NRCS has taken the necessary steps (Annex 1). Sorghum is a health food for diabetics and has a low gluten content. The consumption of sorghum flour, sometimes blended with other flour, and snacks is increasing due to its nutritional value and to increased awareness and new methods of cooking. In particular, wealthier urban consumers are consuming increasing quantities of sorghum, which indirectly benefits poor farmers by providing more marketing opportunities.

In addition, a large number of frontline demonstrations were conducted from 2003-04 to 2005-06 to promote the new varieties in the three states (Table 7).

Table 7. Frontline demonstrations (FLDs) under AICSIP in Mahrashtra during 2005-06 for promotion of new varieties

Variety	When	Where	No. of FLDs	Area (ha)	Grain yield increase over local (%)
Mauli	2003-04	Rahuri, Solapur (Mah)	58	58	67%
Mauli	2005-06	Parbhani, Rahuri, Solapur (Maharashtra)	40	17	75%
P. Yashoda	2003-04	Rahuri (Mah) Parbhani (Mah) Solapur (Mah), Bijapur (Karn) Dharwad (Karn) Tandur (AP), Surat (Guj)	318	318	129%
P. Yashoda	2004-05	Parbhani (Maha), Tanduri (AP), Bijapur (Karnataka)	42	33	64%
P. Yashoda	2005-06	Parbhani, Rahuri, Solapur (Maharashtra)	37	16	80%
Pabhani Moti	2003-04	Parbhani	47	47	39%
Pabhani Moti	2004-05	Parbhani, (Maharashtra)	19	8	53%
Pabhani Moti	2005-06	Solapur, Parbhani, (Maharashtra)	13	6	54%

NRCS is also promoting the new varieties in all three states as good quality fodder for animals because of their resistance to charcoal rot disease. Animal feeding trials are being conducted with various species of livestock, and the use of sorghum grain and forage may prove to be a viable alternative to other fodders in goat and sheep rations.

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)****.*

There is a long gap between release and dissemination in the government sector. Phule Yashoda was released in 2000, Mauli in 2002 and Parbhani Moti in 2003, but the scale of seed production by MSSC (see Q 14) is very small and the varieties have not yet completely entered the official seed production system.

A possible alternative is an increased role for the private sector. However, the formal private sector sees investments in more favourable agricultural areas as far more profitable, and this is exacerbated for what are perceived to be ”poor people’s” crops such as *rabi* sorghum, where seed demand is low in comparison to that for the main season sorghum hybrids. The other private sector is the farmers themselves. However, for this to work requires continual input from senior NGO staff, and such a system will not be sustainable unless the producer groups are directly linked to the market for the seed they produce. This has not happened so far.

Seed production by GOs is dependent on actual orders for seed (called indents), which resource-poor farmers cannot raise themselves, and the State Departments of Agriculture are slow in placing the indents with the seed producing agencies. This is another reason why there is yet to be a reasonable amount of seed production by GOs.

Despite farmers clearly benefiting from out-of-state varieties, official seed channels such as the State Agricultural Universities, the Departments of Agriculture, and the extension system do not promote non-released varieties within a state, which limits seed production and dissemination in AP and Karnataka for those varieties only released in Maharashtra. This discourages the private seed sector, whose failure to deliver new varieties is also influenced by the overly-narrow official demarcation of recommendation domains of new varieties. For example, the varieties Mauli and Parbhani Moti were preferred by farmers in all three states, but were only released in Maharashtra. Clearly there is a need to better define the recommendation domains of varieties by testing them widely with farmers.

Changes in seed regulatory frameworks to encourage the participation of farmers are required. There is also a need for farmers’ preferences to be translated into a demand for seed production. In order to influence policy changes, policy advocacy at a higher level is required.

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 action to remove the barriers would be to raise awareness of the characteristics and value of the new varieties at all levels (State Agricultural Universities, NGOs, Departments of Agriculture, the private sector, and farmers), and over the whole of the wide geographical area to which they are adapted. There is a lack of awareness of the new varieties because the results are new, and because of the constraints to delivering the seed of new varieties, particularly for those that are out-of-state recommendations (see Q17).

The involvement of private-sector seed companies would enhance the take up of new varieties. One option is private-sector (community based) seed production for which capacity building is required, with training in the economics and production of truthful seed.

The following will be key to removing the barriers:

- Raise awareness with the state extension agencies for participatory evaluation of out-of-state released varieties with farmers.
- Promote farmer-preferred varieties irrespective of their state recommendation.
- Include such varieties in the state list of recommendations so that they qualify for seed

subsidies.

- Raise awareness among NGOs and the private seed sector to begin seed production and delivery of such varieties in areas where they are not currently recommended but are preferred by farmers.
- Training in business and marketing for the NGOs and GOs involved in seed production
- Removal of the barriers to direct private sector collaboration with community-based seed production groups.

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 such as Maldandi or M35-1 produces spectacular increases in both grain yield and in quality of grain. It also adds immensely to the attractiveness of a new cropping system by allowing more options due to the earlier maturity or different adaptation of some of the varieties. For instance Mauli grows in shallow soils where M35-1 does not perform well.

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. However, for scientists and extensionists trained in the transfer of technology model the compatibility is lower.

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 complexity for scientists and extensionists trained in the transfer of technology model is moderate, as they need to learn a new range of participatory techniques, although these are largely simpler than those currently used.

4. The observability of a technology in terms of how easy it is to demonstrate and observe performance;
The observability is high for most traits (e.g. maturity, yield), although less so for grain quality.

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, but not possible without seed and information concerning varietal characteristics. Farmers grow new variety alongside their own variety without changing the management.

Hence provision of a sustainable seed supply is the most important factor in getting this research into use. In relation to this, in Q18 key factors were identified that include awareness raising amongst all of the stakeholders in the innovation system, and the role of the non-formal private sector in sustainable seed supply.

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.

No additional impact studies other than the participatory varietal trials were carried out to record farmers' perceptions of the new varieties, of which the following, recorded in focus group discussions and household level questionnaires, are important:

Phule Yashoda (SPV 1359 or CSV-216R): Higher grain yield; bold grains; stems sturdy; no sweetness in stem; fodder not preferred by cattle due to poor quality; better flour recovery with good keeping quality.

Parbhani Moti (SPV 1411): Very bold and lustrous grains; moderately high grain yield; fodder of good quality and preferred by cattle; good threshability and better flour recovery; good *roti* quality with better keeping quality.

Mauli (RSLG 262): Moderately grain yielder; fodder preferred by cattle; low incidence of aphid; excellent drought tolerance.

The NRCS has published five '*sorghum crop profiles'* in five different Indian regional languages for different states. The enthusiasm with which farmers of Maharashtra, Karnataka and Andhra Pradesh tested and adopted the new varieties revealed that they perceived significant improvement in their livelihoods.

The impact and perceptions were summarised in the Final Technical Report of the project and reflected in the following publications:

Rana, B.S., Kaul, S.L., Appaji, C., Reddy, B.V.S, Witcombe, J.R. and Virk, D.S. 1998. "Farmers Participatory Varietal Selection aimed at improving *rabi* sorghum productivity in India". *in* the workshop on "Farmer participatory methods in research and development for semi-arid tropics" on 27-28 October, 1998 at ICRISAT, Hyderabad, India.

Rana, B.S., Kaul, S.L. Appaji, C., Prabhakar, Shetty, K., Reddy, B.V.S., Witcombe, J.R. and Virk, D.S. 2000. "Participatory varietal selection in rabi sorghum in India". In the International conference on "Participatory plant breeding and plant genetic research" held at Pokhara, Nepal, on 1-5 May , 2000.

Financial analysis: The new varieties gave up to 47% more grain yield than the local check. Assuming a more moderate yield increase of 20% from new varieties, covering only about 10% of the *rabi* sorghum area will give 75,000 t of additional grain per year. At a price of Rs 8,000 t^{-1}, (=£96.4 t^{-1}) with an exchange rate of £1 = Rs 83 this is a total benefit of more than £7 M per year.

In fact the benefit to farmers is greater due to the higher fodder yield of the new varieties and their better market price as a result of the bolder grains. Additional benefits can also accrue from large scale seed distribution and production of the varieties on more than 10% of the assumed adoption area, and the rate of return will increase anyway after a few years with greater use of farm-saved seed and the increased participation of GOs and the private sector in seed production.

Table 7. Financial analysis of benefit from new varieties

State	Total area (M ha)	Total production (M t)	Additional production (M t)†	Additional benefit (£ M) †
Maharashtra	3.5	2.10	0.042	4.04 M
Andhra Pradesh	0.5	0.35	0.007	0.67 M
Karnataka	1.6	1.28	0.026	2.47 M

† For assumptions of additional production and exchange rates see text.

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 impact on adoption of new varieties: The participating farmers have rapidly adopted their preferred varieties. Farmers' perceptions about the new varieties were for good cooking quality to make *rotis,* and drought resistance (See Q 20). Farmers saved seed from the on-farm trials, procured it from other farmers, or purchased it from the Department of Agriculture after the varieties were released.

Yield increases: Over all the trials between 1999-00 and 2001-02, the new varieties gave 19 to 47% more grain yield and 14 to 43% more fodder yield than the most popular variety of *rabi* sorghum, M35-1 (Table 1). Mauli was lower yielding by 5% than M35-1, but yielded 20% more fodder. However, Mauli was specifically adapted to shallow soils where it yielded 20% more than M35-1. All the new varieties were comparable to M35-1 for time to maturity (Table 1).

The yield gains clearly show that all participating farmers benefited from the new varieties. There was a substantial increase in grain production and availability for the poor people. This illuminates the need for large scale dissemination and scaling-up of the new varieties.

The effect of yield increases on the livelihoods of people was not apportioned in terms of assets (although all of the assets of the livelihoods framework have been considered in the many impact assessments on other crops, PSP Dossier 16), but the increased yields reduced poverty and increased the food security and purchasing power of the participating farmers, who improved their living standards by using the additional income from the increased yields.

Poor people, including women farmers, benefited the most from the outputs. The potential impact will be on the 5.6 M ha where *rabi* sorghum is currently grown in Maharashtra, Karnataka and Andhra Pradesh. In Maharashtra, 75% of the sorghum area is sown in the *rabi* season, and this is the major target area for the impact. Farmers' yields are only 0.6 t ha^{-1} in Maharashtra, 0.7 t ha^{-1} in AP and 0.8 t ha^{-1} in Karnataka, so the increased yields of the new varieties will benefit the farmers tremendously.

There are 76 M people in AP, 53 M in Karnataka and 97 M in Maharashtra, a total of 226 M in the three states. If we assume that 50% live in villages, then the impact of new varieties will be on nearly 113 M people. Demand from urban people for sorghum is also increasing (See Q 16) because of its low gluten content and slow digestibility, making it suitable for diabetics. The increased demand benefits the poor by selling greater quantities of sorghum at increased prices. This also benefited the women in the households by empowering them with increased role in storage, processing and marketing.

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 adoption of out-of-state released varieties and PVS process will reduce the national wastage of breeding and testing of varieties that farmers will ultimately reject.
- 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.
- Varietal diversification will help reduce crop loss due to pests and diseases and so reduce the use of pesticides. The introduction of new varieties increased on-farm diversity as farmers adopted many more varieties. This had a positive effect on on-farm diversity and provided insurance against the disease dangers of monocultures.
- Increased productivity of from 0.3 t ha^{-1} for Phule Yashoda to 0.6 t ha^{-1} for Parbhani Moti, and increased fodder yield by from 0.64 t ha^{-1} for Mauli to 1.23 t ha^{-1} for Parbhani Moti compared to the previously popular variety M35-1 will reduce the pressure to increase the area under cultivation (Evenson and Gollin, 2003).
- The higher fodder yields of the new varieties will reduce deforestation for fuel wood and fodder. It will also have positive effects on animal health and milk and meat production.
- The better disease and pest resistance of the new varieties reduces the use of water polluting agro-chemicals and reduces soil pollutants. Lower applications of pesticides and insecticides also reduced the risks to human life and helped in the creation of a balanced pest-predator cycle and in the regeneration of the micro-ecosystem.

Effect on policy: Adoption of a number of varieties by farmers indicated the possibilities of releasing several varieties at the same time instead of choosing the best one at the time of release. Because of the release of multiple varieties there would be more options for farmers, policy makers and NGOs who wish to promote diversification.

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)***

The focus group discussions and household level questionnaires during the monitoring of the trials have indicated increased benefits from enhanced grain and fodder yields from the new varieties. Under severe drought conditions sorghum is the only cereal crop that can grow well and provide farmers with food. The new varieties are recommended in areas where M35-1 grows without changing the input levels, and so are neutral to climate change.

The resource-poor farmers intend to adopt many additional varieties than the single variety (M35-1) and a few landraces they used to cultivate. Varietal diversification is a means of coping with climate change because staggered deployment of varieties in different soil types will spread out water demands and reduce the risks from natural disasters such as diseases, pests and other calamities. Deployment of new varieties that do well under varied soil depths increases the resilience of farmers to cope with natural risks. The adoption of many varieties simultaneously has increased the cropping options for farmers, allowing them to take up a range of possibilities of **crop scapping** and sequencing.

Farmers' resilience has increased with the introduction of the new varieties as they are suitable for intercropping with chickpea or safflower. Chickpea is useful in checking malnutrition among poor people, and also to improve the fertility of poor soils. Safflower oil is low in saturated fatty acids, and provides a healthy option in diets.

Annex

References

Evenson, R.E and Gollin, D. 2003: Assessing the Impact of the Green Revolution, 1960 to 2000. Science 300: 758 – 762.

Rogers, E.M. (2003). Diffusion of innovations. 5th Edition. New York: Free Press.

Witcombe, J.R. 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 Baños, 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, pp. 79.
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.