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Impact of ICRISAT Pearl Millet Hybrid Parents Research Consortium (PMHPRC) on the Livelihoods of Farmers in India

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Key definitions used in the report

HPRC hybrid : Pearl millet hybrid bred by HPRC members using ICRISAT parental lines

NHPRC hybrid : Pearl millet hybrid bred by non-HPRC members without using ICRISAT parental lines

PSC : Currently not an HPRC member but was previously and accessed ICRISAT-bred lines

SC : Current HPRC member and have has access to ICRISAT parental lines

Local : Landraces cultivated locally

Standard unit conversions

One ton (T) : 1,000 kilograms (kg)

One quintal (qtl) : 100 kilograms

One acre : 0.404 hectare (ha)

One million : 10,00,000

List of Abbreviations

AICPMIP	All-India Coordinated Pearl Millet Improvement Project
AICRPDA	All-India Coordinated Research Project for Dryland Agriculture
BCR	Benefit-Cost Ratio
CCSHAU	Chaudhary Charan Singh Haryana Agricultural University
COC	Costs of Cultivation
COP	Costs of Production
FAO	Food and Agriculture Organization
FCDS	Food Characteristic Demand System
FCI	Food Corporation of India
HOPE	Harnessing Opportunities for Productivity Enhancement of Sorghum and Millets in Sub-Saharan Africa and South Asia
HPRC	Hybrid Parents Research Consortium
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IPGs	International Public Goods
KVKs	Krishi Vigyan Kendras
MPKV	Mahatma Phule Krishi Vidyapeeth
MRS	Millets Research Station
MSP	Minimum Support Price
NARP	National Agricultural Research Project
NARS	National Agricultural Research Systems
NFSA	National Food Security Act
NFSM	National Food Security Mission
NGOs	Non-Governmental Organizations
OPVs	Open Pollinated Varieties
PDS	Public Distribution System
PM	Pearl Millet
PPP	Public-Private Partnerships
PSC	Previous Seed Company
QUAIDS	Quadratic Almost Ideal Demand System
R & D	Research and Development
SAUs	State Agricultural Universities
SC	Seed Company
SURE	Seemingly Unrelated Regression Estimates
TC	Total Costs
TVC	Total Variable Costs
UCR	Unit Cost Reduction

Executive Summary

Highlights of the study

- ICRISAT commissioned a third-party evaluation in 2015 to assess 'on-farm impact of pearl millet HPRC hybrids' developed during 2000-2010.
- The study covered 563 pearl millet growers spanning 57 villages and 25 mandals from three states (Rajasthan, Gujarat and Uttar Pradesh) in India.
- HPRC hybrids covered about 60% of pearl millet hybrid area in the three states during 2013-14.
- HPRC hybrids have provided at least 20% higher grain and fodder than the varieties/other hybrids they replaced.
- Total benefits accrued due to HPRC hybrids in the three states added up to US$133.7 million per year.
- Benefits could surpass US$150 million per year at country level if we include the contribution of HPRC hybrids in other states of India.

Pearl millet is one of the most important food crops grown across the drylands of Africa and Asia, predominantly in low-rainfall environments with infertile soils. In India, while the area under production has marginally declined, productivity has increased three- to four-fold over the six decades to date due to efforts in crop improvement and practices. The development and wider use of hybrids was primarily responsible for the phenomenal yield increases achieved. Till 2000, ICRISAT helped both the public and private sector companies by providing downy mildew resistant and high-yielding varieties, hybrids and parent materials to them informally.

ICRISAT established the Hybrid Parents Research Consortium (HPRC) for pearl millet in 2000-2001 to strengthen the Public-Private Partnership (PPP) model, under which companies pay fees for access to parent materials to develop better hybrids. The impact of HPRC on the development of hybrids through extensive use of parental lines by the members was studied in the HPRC-I study. As a logical follow up to it, ICRISAT commissioned the present study to estimate the coverage of the pearl millet area by the HPRC hybrids in the field and to assess the impacts in terms of the cost saving to the farmers resulting from high yields when compared with the non-HPRC hybrids. This study was conducted with a sample of 563 pearl millet growers from the three major pearl millet growing states of Rajasthan, Gujarat and Uttar Pradesh.

The patterns of first adoption across states revealed that the initial adoption lag to reach the peak level of adoption was estimated at 4-5 years. The hybrids exclusively preferred by farmers were sustained in the market for about 9-10 years. It was estimated that the HPRC hybrids covered 59.5% of the pearl millet area in these states during 2013-14. However, the extent of area covered by HPRC hybrids was 75% in Gujarat, while it was 49% in Rajasthan and 62% in Uttar Pradesh. They yielded much higher grain and fodder yields than the hybrids replaced by them and the non-HPRC hybrids. They gave much higher benefit-cost ratios than the hybrids replaced and non-HPRC hybrids. Farmers reaped substantial private benefits by the adoption of HPRC hybrids.

Besides the private benefits, the social benefits were also substantial. HPRC hybrids succeeded in reducing the unit cost of production to the farmers by US$3.46 in Gujarat, US$2.49 in Rajasthan and US$1.97 in Uttar Pradesh per quintal (100 kg) of grain produced. The social benefits due to HPRC hybrids were estimated at US$39.5 million in Gujarat, US$55.2 million in Rajasthan and US$39.0 million in Uttar Pradesh per year. The total benefits from HPRC hybrids could surpass US$150 million per year, if the HPRC hybrid coverage in other states is also considered. But all these social benefits do not accrue to the farmers alone. Due to low income and price elasticity of demand, most of the social benefits accrue to the consumers. Some benefits accrue to seed companies and seed dealers.

The sampled farmers perceived huge benefits from hybrid technology in terms of grain yield, fodder yield, grain quality, fodder quality, disease resistance, duration, etc. Although the input use has increased, it was more than compensated for by high yields. It was found that the sustainability indicators of pearl

millet cultivation improved in case of Gujarat and Rajasthan, although there is room for concern in case of Uttar Pradesh. Pearl millet's position as a supplier of grain and fodder improved in case of Gujarat, while its role was weakened slightly in the other two states. However, it continues to receive good quality land allocation in all the three states. But some farmers, notably in Rajasthan, have started shifting it to relatively poorer quality lands. It is profitable and competitive with some crops while there are other rainy season crops that are more profitable in the study states.

The income and expenditure data indicate that the sampled farmers are able to save some money after meeting their livelihood expenses. This margin was quite small in the Rajasthan sample, moderate in Gujarat and substantial in Uttar Pradesh. The average annual household income was US$3,418 in Uttar Pradesh, US$1,691 in Gujarat and US$1,564 in Rajasthan. In terms of per capita income, Uttar Pradesh is better placed with a per capita income of US$387.09 per year. The Gujarat sample had a per capita income of US$300.36 due to smaller family size. The Rajasthan sample was the poorest with a per capita income of US$206.88 per year. However, the difference in consumption expenditure was not wide as in the incomes. Uttar Pradesh sampled farmers spent US$1693 per year, while these figures for Gujarat and Rajasthan were US$1,260 and US$1,500 per year, respectively. In terms of per capita expenditure, Gujarat was better placed with US$223.80, than Rajasthan (US$198.41) and Uttar Pradesh (US$191.73). But all the sampled farmers spend less than one US dollar per day and fit in to the definition of poor by the World Bank standards.

In North Gujarat, the dependence of sampled farmers on pearl millet for the supply of grain and fodder has increased over the last 10 years. But this dependence has weakened in Rajasthan and Uttar Pradesh samples during the last 10 years due to the availability of alternate food and fodder sources. However, pearl millet is sure to survive as a competitive crop in all the three states. Farmers expect that both the grain and fodder yields will further go up with the upcoming hybrids. Better hybrids with high yields, improved quality and resistance to abiotic and biotic stresses would help in improving the competitiveness of pearl millet in these states. Farmers also want higher minimum support and market prices to realize higher profits so that they can come out of the poverty trap.

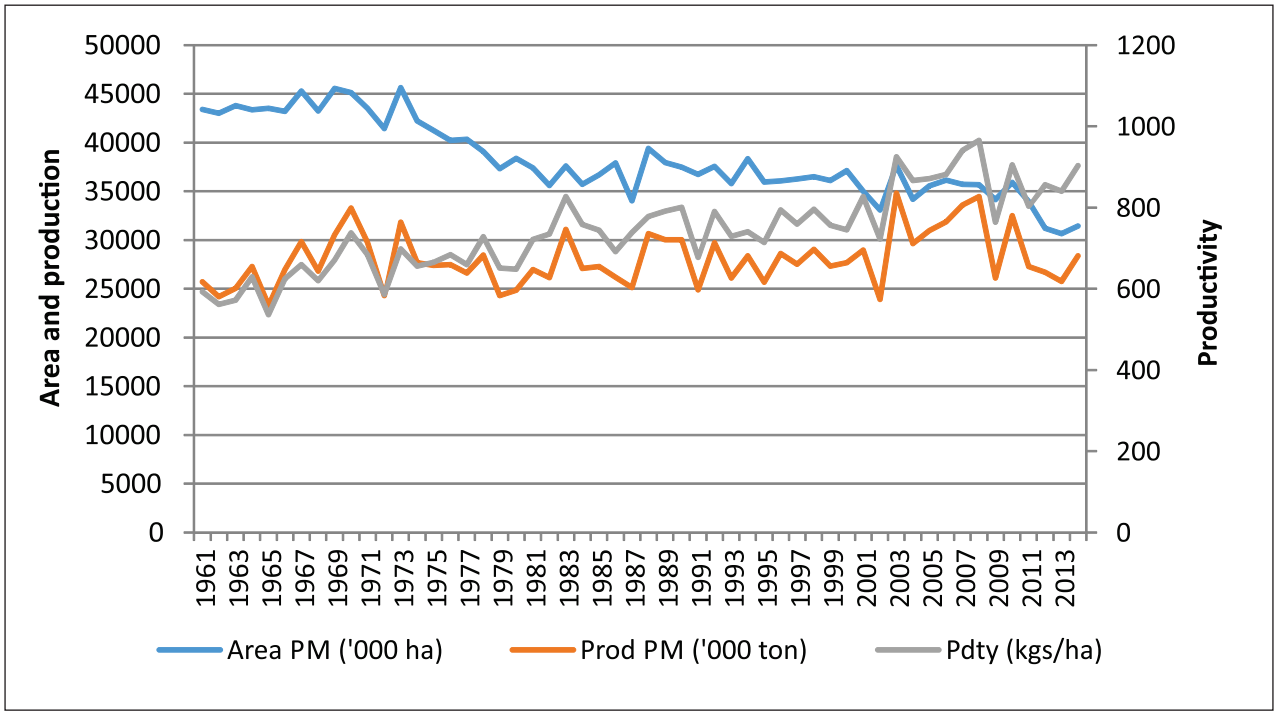
Chapter 1

Introduction

1.1 General overview

Pearl millet (*Pennisetum glaucum* (L) R. Br.emend.Stuntz) is an important food crop in arid and semi-arid tropics of the world, particularly in areas of low rainfall and shallow soils. Being shorter in duration, it is the most drought-tolerant cereal grown in these regions and it is the staple food for many people. It is the sixth most important food cereal in the world. Globally, the area under millets[1] displayed a declining trend after 1973, reaching 31.4 million ha by 2014-15 compared to 43 million ha in 1961-62 (see Figure 1.1). But the production showed an increasing trend and touched 35 million tons in 2003. However, over the last 54 years it has again fallen back to the starting level of 28 million tons. Productivity increased from 600 kg per ha in 1961 up to 965 kg per ha in 2014-15 (FAOSTAT 2016). Productivity growth has ensured that the production did not fall despite a regular decrease in the area under millets (Bhagavatula et al. 2013).

Pearl millet is one of the most important sources of staple food and fodder in the predominantly rainfed areas of the country. Its grain has very high nutritive value for human consumption and livestock also relish its straw, both in fresh and dried forms. The area under pearl millet declined from 9.02 million ha in 1950-51 to about 7.31 million ha by 2014-15 in India. But its production increased from 2.6 million tons in 1950-51 to 9.18 million tons in 2014-15. This rapid increase was possible because of trebling of productivity from 288 kg per ha in 1950-51 to 1,255 kg per ha in 2014-15. It is largely a rainfed crop, except when it is grown as a summer crop when it generally receives the support of irrigation. Overall, only 10% of the pearl millet area is irrigated in India. A rapid increase in pearl millet yield was possible because of the introduction of hybrids in all the regions, perhaps with the exception of West Rajasthan



Source: FAOSTAT, 2016

Fig.1.1. Global trends in area, production and productivity of millets, 1961-2014.

[1] Pearl millet contributes nearly half of the global millet area (http://pdf.usaid.gov/pdf_docs/PNACA387.pdf)

where landraces/Open Pollinated Varieties (OPVs) are still grown due to an extremely risky production environment. Rajasthan, Uttar Pradesh, Maharashtra, Gujarat and Haryana are the five most important states for pearl millet, together accounting for 92% of the pearl millet area and production in the country (Kumara Charyulu et al. 2014b).

The All India Coordinated Pearl Millet Improvement Program (AICPMIP), spearheaded by the Indian Council of Agricultural Research (ICAR), has collaborators from the State Agricultural Universities. It started developing hybrids and composite varieties from the late 1960s. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), which was set up in 1972, is engaged in the genetic improvement of pearl millet by making use of the wide germplasm collection it holds. It made notable contribution in developing resistant varieties to downy mildew, the most dreaded disease of the crop, which often threatens to wipe out the crop. Till 1999, it collaborated informally with private companies and helped them in evolving several successful hybrids with resistance to downy mildew. During this time, about 70 hybrids/composites of pearl millet were developed by the private and public sector companies, which together occupied about 5 million ha area in the country. About 60 out of 70 hybrids developed by private seed companies used parental lines supplied by ICRISAT. These hybrids have contributed significantly to enhancing genetic diversity, productivity and yield stability, and thereby impacted the lives of poor dryland farmers in the country. Having recognized the importance of private seed companies and their network of seed dealers, ICRISAT collaborated with them through informal networks.

1.2 Setting-up of HPRC

The interaction with the private seed sector was informal and passive in 1990s, although it continued to derive immense economic benefits from ICRISAT's research products. With a view primarily to engage the private sector in more active partnership to hasten the pace and scale of impact, and to generate research funds to provide partial support to pearl millet improvement research at ICRISAT, a consortium model was conceptualized as the most appropriate among various partnership models, and hence the Hybrid Parents Research Consortium (HPRC) was established in 2000 (Mula et al. 2007; Reddy BVS et al. 2006). HPRC started with 9 members in 2001 and it grew to 40 seed member companies by 2008. Every member of the HPRC contributes a small grant every year. It started functioning in the first phase (2000-04), followed by the second phase (2005-09), third phase (2010-13) and the fourth phase (2014-17). By the end of the fourth phase, there were nearly 38 seed companies as its members (see Figure 1.2). The consortium members receive the hybrid parent materials, A- and B- lines, progenies and restorer lines from HPRC.

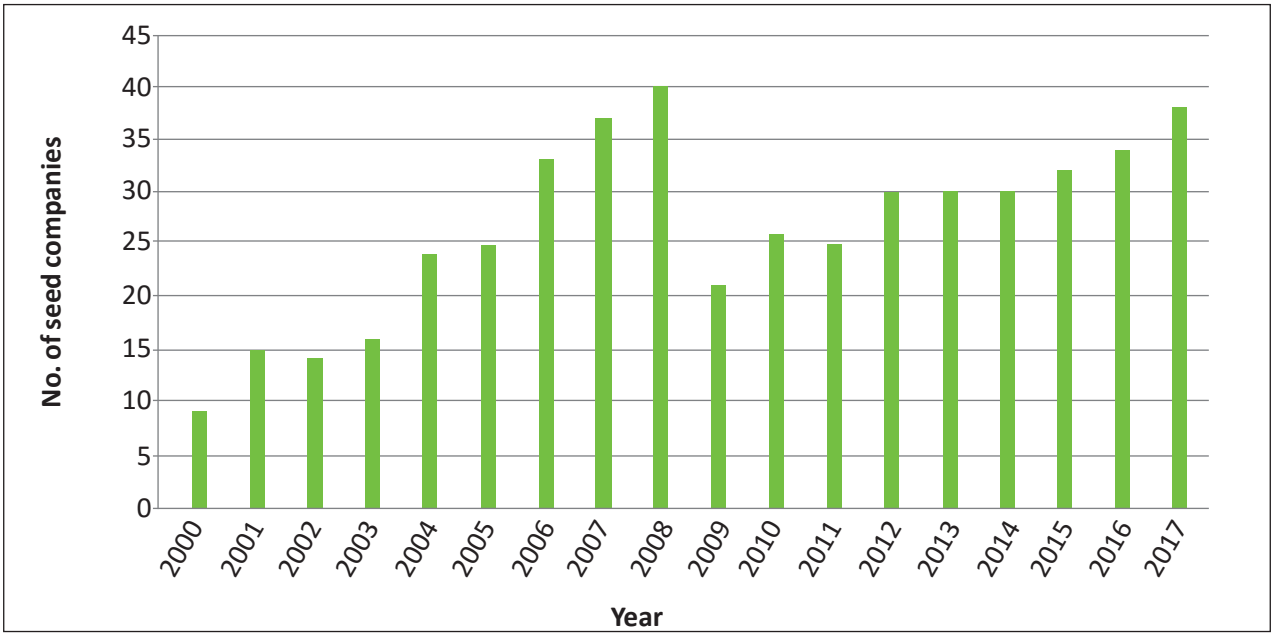


Figure 1.2. Trends in HPRC membership over time, 2001-17.

Ideally, this type of public-private partnerships (PPPs) reduce transaction costs in the exchange of knowledge and suggest that the research centers widen their focus from research for technological innovation to inventions at both a systemic/societal and an internal/organizational level. Such partnerships and co-funding are likely to hasten the pace of technology development and its transfer to farmers. On the other hand, these partnerships also enable pooling of resources and minimize the risks in R&D investment for mutual benefit. The realization for the need of partnerships with the private sector has become more pertinent both in terms of financial support to ICRISAT as well as generating wide-scale research impacts on the ground. This has finally led to the initiation of a consortium on pearl millet (in 2000) at ICRISAT, the first of its kind in the entire CGIAR system. The National Agricultural Research System (NARS) has equally benefited from this since they play an important role in the development and exchange of germplasm materials. The most significant aspect of this arrangement is that the products developed with the consortia are International Public Goods (IPGs) and made freely available to both public and private sector members. On the whole, the HPRC was implemented by ICRISAT to align the research focus of the institute with the regional priority of the NARS and the rapidly expanding private sector.

1.3 Hybrid Parents Research Consortium (HPRC) - I study

ICRISAT conducted a study (HPRC-I, pearl millet), involving a social scientist and a plant breeder, by sending a questionnaire to its members in Phase-III and five representative NARS centers to assess the impact of the Public-Private Partnership (PPP) during 2013-14. About 21 members responded and the initial feedback was encouraging. This PPP led to the development of the most successful hybrids for which the parents were developed and provided by ICRISAT and the restorers were generated by the private sector companies. Thirteen of the 21 consortium members significantly made use of the parent lines supplied by ICRISAT and developed more than 70 hybrids. About 68% of the hybrids released by the companies had ICRISAT-bred materials as parental lines during the years 2000-2010. Additionally, 56 hybrids are in the pipeline and are likely to be released in the next few years. Public sector companies also acknowledged that they made use of parent lines from ICRISAT in 19 out of the 25 hybrids (76%) developed by them. They have eight more hybrids in the pipeline which made use of parent lines provided by HPRC and they are likely to be released over the next two to three years. Thus, the research backup to the private and public sector companies is quite strong and the PPP arrangement is likely to contribute to further growth in the productivity of pearl millet. All these hybrids have made substantial contributions to enhance genetic diversity, productivity and yield stability, and have improved the livelihoods of poor farmers in the dry areas (PMHPRC-1 Report). The consortium also provided ample opportunities to enhance the knowledge of personnel from both private seed companies and NARS partners through regular interactions, field days, trainings and workshops. Some of these companies have also released hybrids (34) that have not used parent materials supplied by HPRC. Some companies that are not members of HPRC have also developed and commercialized their own hybrids. Farmers growing pearl millet now have a wide choice of hybrids to select from, to suit their field and agro-climatic conditions. Based on these initial findings, ICRISAT has commissioned the present study (HPRC-II, pearl millet) with the following specific objectives.

1.4 Objectives of Pearl Millet Hybrid Parents Research Consortium – II study

In general, impact assessment of agricultural research has always been viewed as an important activity to ensure accountability, maintain credibility, improve internal decision-making processes, and to learn about constraints from past experiences. As a logical follow-up to the HPRC-I assessment, it was felt necessary to have a field-level study to assess the adoption and impact of the hybrids developed by the private sector seed companies at the farm level with the following specific objectives:

a. To assess the coverage of pearl millet area by the hybrids developed by private seed companies and NARS between 2000 and 2010 using ICRISAT-bred parent materials.

b. To measure the impact of hybrids with ICRISAT-bred parental lines on grain and fodder yields of the pearl millet farmers by comparing them with those of the hybrids replaced by them and with those of the hybrids developed by private seed companies and research institutions without using the ICRISAT parent materials.

c. To compute the incremental benefit-cost ratios accruing to farmers by the adoption of hybrids marketed by companies that made use of the parent materials supplied by ICRISAT

The HPRC-II study covering pearl millet growers from targeted study states also collected feedback to define priorities of future research and resource allocation among programs, and guide researchers to better understand the way technologies percolate to the farmers who get the real benefits from the research products. Comprehensively, both these studies (HPRC I & II) were taken up to determine the extent of utilization of the diversified genetic materials supplied by ICRISAT to partners of both private and public sector, and its impact on hybrid development and delivery to targeted farmers in selected ecologies.

1.5 Layout of the report

The first chapter introduces the research problem after providing a general introduction and overview. The second chapter analyzes the secondary data to develop a broad understanding about the performance of pearl millet at the all-India level and at the level of important pearl millet-growing states in terms of area, production and productivity, and provides justification for selection of districts for the detailed study in the selected states. The third chapter reviews the historical development of the improved varieties and hybrids and the role of HPRC-pearl millet in accelerating the pace of development of improved pearl millet hybrids. It also presents an overview of the policy parameters that adversely impact coarse grains in general and pearl millet in particular, and examines supply-demand dynamics. The fourth chapter details the sampling frame for the study. The fifth chapter indicates the steps followed in the conduct of survey and the analysis of data. Chapter Six presents the results and discusses the implications of the results. Chapter Seven summarizes the study and draws some conclusions to meet the objectives and research questions framed in the study. At the end, relevant references are cited.

Chapter 2

Performance of pearl millet in India and major states

2.1 Pearl millet at all-India level

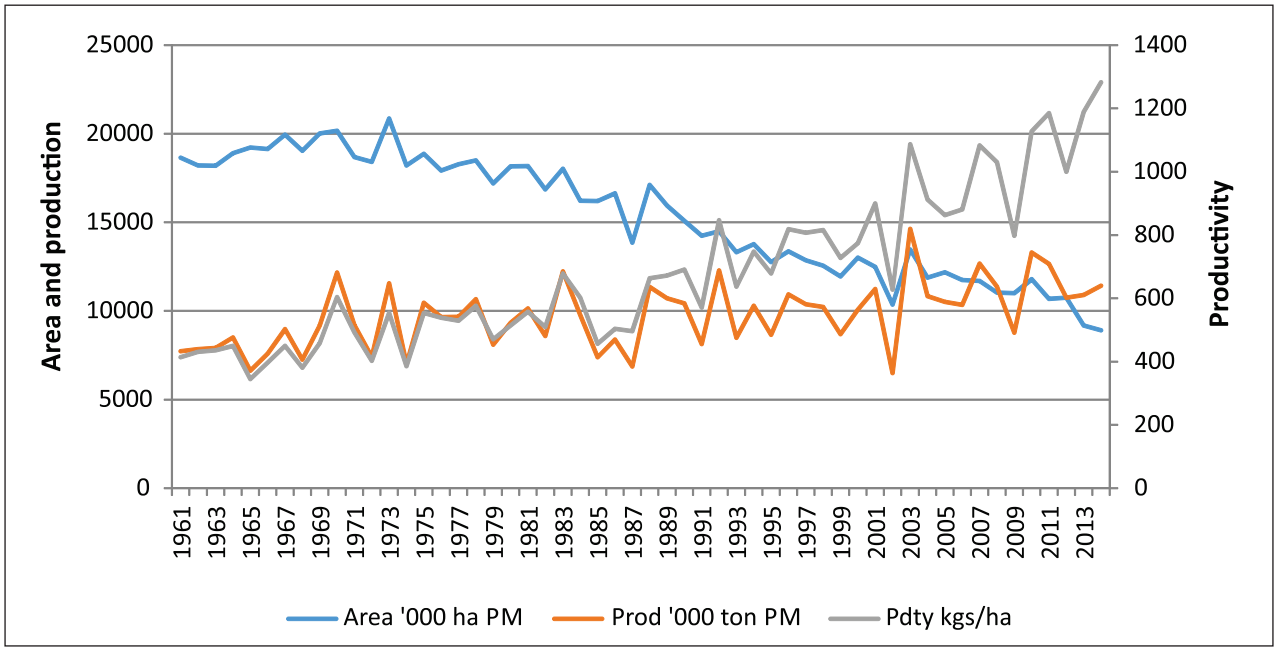
In 1970-71, the area under pearl millet was 12.91 million ha but it started steadily declining over the next four decades to reach 7.31 million ha in 2014-15 (Table 2.1). The area under pearl millet in India has decreased by 15.78% even during the recent period between 2010-11 and 2014-15. However, over four-and-a-half decades, the production of pearl millet has registered a small increase of 1.15 million tons. In fact, it decreased by 0.69 million tons in the decade between 1970-71 and 1980-81. It remained below the 1970-71 level till 2000-01. But during 2010-11 to 2014-15, it registered an increase of 6.6%. However, productivity dropped only in the first decade (1970-71 to 1980-81) and recovered in the next two decades. It grew by 27% during the recent period between 2010-11 and 2014-15. Irrigation coverage increased from 4% in 1970-71 to 8.3% in 2010-11. Although figures for 2014-15 are not available, they must be higher because of the increasing practice of growing summer pearl millet in several states (GOI 2016; Bhagavatula et al. 2013).

The area, production and productivity details of pearl millet at the all-India level from 1970-71 to 2014-15 are plotted in Figure 2.1 in blue, maroon and green colors, respectively. Pearl millet area reached a peak in 1972-73 (about 14 million ha) but has shown a declining trend since then. By 2014-15, it reached a level of

Table 2.1. Performance of pearl millet in India, 1970-2015.

Item	1970-71	1980-81	1990-91	2000-01	2010-11	2014-15
Pearl millet area (million ha)	12.91	11.66	10.48	9.83	8.68	7.31
Pearl millet production (million tons)	8.03	5.34	6.89	6.76	8.61	9.18
Productivity (kg/ha)	622	458	658	688	991	1255
Share of area under irrigation (%)	4.00	5.50	5.10	8.00	8.3	NA

Source: Ministry of Agriculture, Government of India, 2016



Source: Ministry of Agriculture, India

Figure 2.1. Performance of pearl millet in India, 1971-2014.

7.31 million ha. Despite the fall in area, the production of pearl millet increased from 8.03 million tons in 1970-71 to more than 9.18 million tons in 2014-15. The production of pearl millet did touch a peak of 12 million tons in 2003-04 but dropped later due to a steep fall in area. Then again, there was a rapid growth in productivity of the improved hybrids/varieties and other production technologies. Productivity of pearl millet also increased by 82% during the last one-and-a-half decades.

The sharp rise in production despite decreasing area is due to a consistent increase in productivity due to better varieties/hybrids and other improvements in cultivation practices. The productivity figures for different years are mapped and a trend line was fitted as shown in Figure 2.2. Productivity peaked in 2003-04, crossing 1,100 kg per ha. Even in 2014-15, it was around 1,255 kg per ha. It represents more than a doubling of pearl millet yield between 1970-71 and 2014-15. The trend line fitted to the productivity data is a fairly good fit, as it explained about 73% variability in productivity. It also gave a prediction that the productivity of pearl millet has been increasing at the rate of 17 kg per ha per year between 1970-71 and 2014-15 (Bhatnagar et al. 1998).

Figure 2.3 shows decadal trends in productivity of pearl millet at the all-India level. These linear decadal trends are poor fits of the data. Productivity marked a declining trend during the 1970s but registered positive trends in the next three decades. During 1970s, HB3 succumbed to downy mildew and the crop was endangered. This might be one of the reasons for the declining trend during 1970s. But, owing to poor and non-significant trend equations, nothing can be concluded firmly about the productivity trends in the decadal periods.

2.2 Pearl millet in major states

In terms of area under pearl millet, Rajasthan stands out as the number one state, with a share of about 57% in the country's area during 2011-15 (quinquennial average). Uttar Pradesh comes a distant second with a share of about 11.2%. Maharashtra, Gujarat and Haryana occupy the next three places with shares of 10%, 8.5% and 6%, respectively. These five states together had a share of 93% in the total area. However, Rajasthan accounted for only 44% of the pearl millet production in the country since it achieved productivity level of only 918 kg per ha (see Table 2.2).

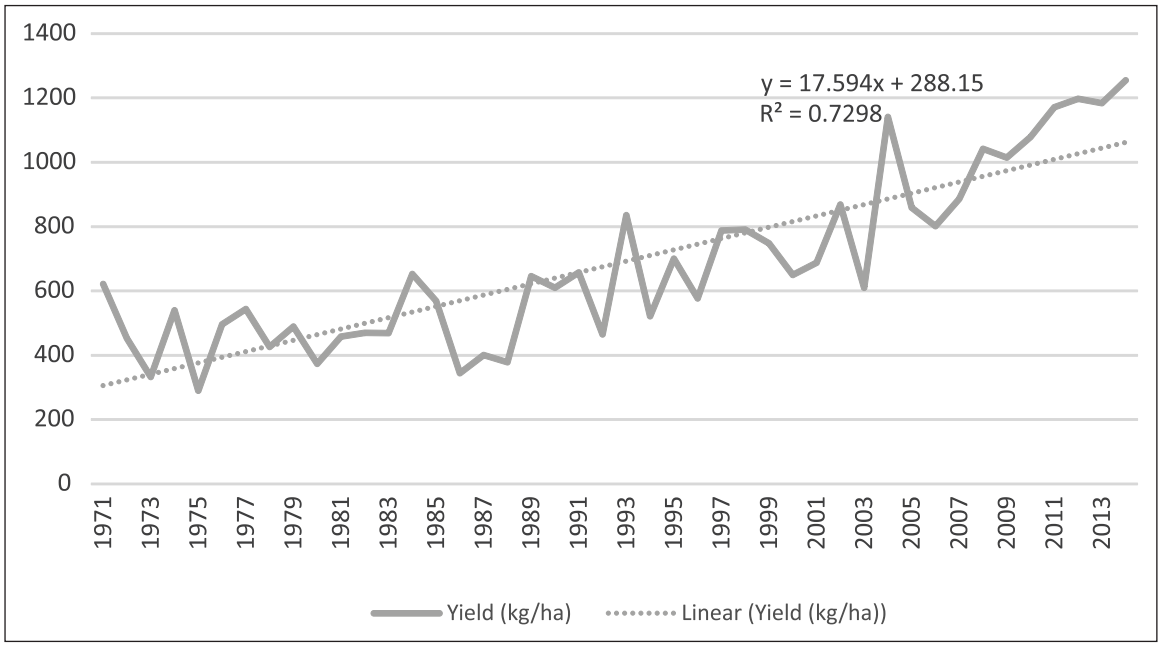


Figure 2.2 Productivity of pearl millet in India, 1971-2015 (kg per ha).

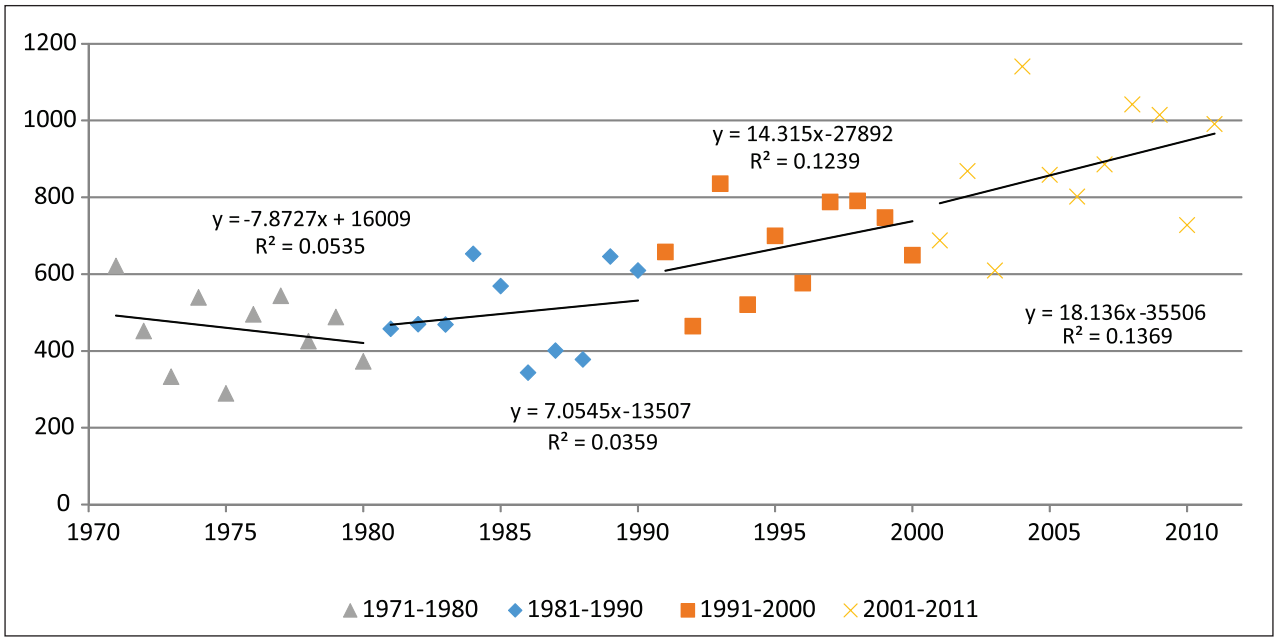


Figure 2.3 Productivity trends of pearl millet at all-India level (kg per ha), 1970-2011.

Table 2.2. Area, production and productivity of pearl millet in major producing states.

(Area – million ha; Prod – million tons and Yield – kg per ha)

State	1976-1978			1986-88			1996-1998			2008-2010			2011-15		
	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield
Rajasthan	4.07	1.09	272	4.85	1.39	265	4.53	2.20	485	5.27	3.62	684	4.60	4.22	918
Uttar Pradesh	0.97	0.67	694	0.80	0.72	897	0.83	1.08	1293	0.86	1.41	1637	0.91	1.72	1877
Haryana	0.90	0.40	447	0.67	0.47	635	0.58	0.71	1214	0.61	1.06	1718	0.48	0.93	1908
Gujarat	1.46	1.27	872	1.18	0.95	748	1.06	1.36	1273	0.74	0.96	1282	0.69	1.06	1531
Maharashtra	1.70	0.62	365	1.83	0.75	409	1.85	1.48	796	0.97	0.85	864	0.85	0.75	880
Madhya Pradesh	0.17	0.11	630	0.16	0.13	785	0.14	0.15	1076	0.16	0.26	1589	0.19	0.35	1877

Source: Directorate of Economics & Statistics

Uttar Pradesh stood second in production with a 17.9% share because of an impressive yield of 1,877 kg per ha. Haryana had a share of 9.6% in production because of a high productivity of 1,908 kg per ha. Maharashtra registered a 7.8% share in production by recording an average yield of 880 kg per ha. Gujarat reported an average yield of 1,531 kg per ha and could contribute to 11% of pearl millet production in the country. These five states together accounted for a 91% share in the country's total production.

The area under pearl millet has increased marginally (13%) in the case of Rajasthan between 1976-78 and 2011-15. Except for Rajasthan, the other five states showed declining trends in area under pearl millet crop. With regard to productivity, Haryana state has registered the highest growth (427%) followed by Rajasthan (338%), Madhya Pradesh (298%), Uttar Pradesh (270%), Maharashtra (241%) and Gujarat (176%) during 1976-78 and 2011-15 average period. Maharashtra lost a significant area under pearl millet during the four decades of study period under analysis. However, production and productivity are on an increasing trend due to adoption of improved cultivars and hybrids in the state.

2.3 Selection of the states and districts for the study

Out of the five major states cultivating pearl millet in India, three states were chosen for the study. Rajasthan, which is ranked as the first state for pearl millet cultivation both in terms of area and production, was an obvious choice. Gujarat and Uttar Pradesh were the other two important states chosen purposively. Maharashtra was avoided as it was studied recently by the Economics program of ICRISAT[2]. Haryana was not considered as it has similar ecology as East Rajasthan. Since the aim of the present study is to analyze the performance of HPRC hybrids, North Gujarat, East Rajasthan and West Uttar Pradesh regions were chosen selectively because of the dominance of hybrid cultivation in these areas during the rainy season.

2.3.1 Selection of districts in the states

Data were collected from the private companies which were members of HPRC-Pearl millet consortia on their seed sales in the three study states. It was found that most of them were focusing on Banaskantha, Mehsana and Patan markets in Gujarat; Jaipur, Alwar, Sikar and Dausa markets in Rajasthan; and Agra, Mahamaya Nagar (Hathras) and Firozabad markets in Uttar Pradesh. Rainy season pearl millet areas are largely concentrated in these selected districts of the three states. Hence, the selection of these ten districts from the three states for this study was felt quite appropriate to achieve the objectives set for the study.

In Gujarat, Banaskantha, Mehsana and Patan districts were selected as the cultivation of hybrids is most popular there. Banaskantha accounts for 33.7% of pearl millet area in Gujarat. Patan district with 7.6% area and Mehsana with 8.2% area shares are also important districts for pearl millet cultivation in Gujarat. These three districts of North Gujarat together have about 50% share in the total pearl millet area of Gujarat state.

In Rajasthan, the study was focused in the districts of Jaipur, Alwar, Sikar and Dausa. These four districts in East Rajasthan have a combined share of 20% in the total pearl millet cultivated area of Rajasthan state. Jaipur, with 6.2% share, is closely followed by Sikar with 6.1% area share. Alwar with 5.0% share and Dausa with 2.6% share are also important pearl millet districts purposively selected in Rajasthan. While these four districts of East Rajasthan have an area share of about 20% in Rajasthan, they account for nearly one half of the hybrid seed sold in the state.

In Uttar Pradesh, the study was targeted in the districts of Agra, Firozabad and Mahamaya Nagar. Agra district has an area share of 12% in the total cultivated area of pearl millet in Uttar Pradesh, while Firozabad accounts for 7.0% share and Mahamaya Nagar (Hathras) for 4.4% share, respectively. They are also important pearl millet growing districts in the state. These three selected districts have a combined share of nearly one-fourth in the pearl millet area in Uttar Pradesh. Their combined share in the hybrid seed sales of pearl millet in Uttar Pradesh would be much higher than their shares in pearl millet cultivated area.

[2] Maharashtra pearl millet study report can be accessed at http://oar.icrisat.org/9993/

Chapter 3

Historical development of improved pearl millet cultivars in India

3.1 Pearl millet system analysis/cropping systems

Pearl millet is generally grown as a rainfed crop in different states of the country during the rainy season. Its spread is restricted to the western part of the country where the length of the growing season is rather short. It is grown as a sole crop as well as a main crop with pigeonpea grown as an intercrop. Rarely, other crops are also intercropped with it. Generally, the land is left fallow during the post-rainy season if there are no facilities for irrigation. Castor, cluster bean, cotton, sorghum and green gram/black gram are the crops competing for land with pearl millet. Wherever irrigation facilities exist, crops such as wheat, mustard and potato are grown in the post-rainy season after pearl millet. In these areas, pearl millet is also grown in the summer due to its ability to produce high yield in a short period.

3.2 Development of hybrids and varieties, 1934-2013

There is a long history of development of pearl millet varieties/hybrids suitable for different parts of the country in the last eight decades (Khairwal and Yadav 2005; Yadav and Rai 2013) (see Table 3.1). Three varieties, N28-15-1, Kopargaon local and Avsari, were developed and released in 1934. These three varieties were selections from local varieties of pearl millet. The Pearl Millet Research Station, Jamnagar, developed and released the first pearl millet hybrid, HB3, with the help of All India Coordinated Pearl Millet Improvement Project (AICPMIP) in 1968. Another hybrid, BJ-104, was developed in 1972 and it became popular in Gujarat, Rajasthan, Maharashtra and Haryana because of its resistance to downy mildew disease. The Indian Agricultural Research Institute (IARI), New Delhi, developed and released another hybrid, NHB-5 in 1975. The National Agricultural Research Project (NARP), Aurangabad, released a variety, AMP2, in 1981. IARI followed up with a variety, Pusa-163, in 1982. Mahyco, Jalna, came out with the first private sector hybrid, MHB-110, in 1982. It followed it up with the marketing of MBH118 in 1985 and MBH130 in 1986. Meanwhile, CCS Haryana Agricultural University released its first hybrid, HHB-45; and Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, developed a variety, Sangam, by selection method from the materials received from ICRISAT. Most of these cultivars could not sustain in the market because of their susceptibility to new strains of downy mildew. Punjab Agricultural University developed PHB10 and PHB14; while these were tolerant to downy mildew, they possessed sharp awns due to which they did not remain in cultivation for long.

ICRISAT combined multiple sources of resistance for downy mildew and started collaborating with universities and the AICPMIP, Pune, and released through them three hybrids – MH179, MH180 and MH182 in 1986. The most notable contribution from ICRISAT was the development and release of the composite variety ICTP8203 in 1988. It was bred from five selected progenies of a landrace from Togo (Pray and Nagarajan 2009). It is popular in Maharashtra even today, nearly two-and-a-half decades after its release. Mahyco, Jalna, developed a number of hybrids starting with MBH136 and MBH149 in 1989, MBH163 in 1993, Mahyco 204 in 1995, Mahyco 2210 in 2007 and Mahyco 2240 in 2010. Vijaya Seeds, Nath Seeds, Mahendra Seeds, ITC Geneca, Ganga Kaveri Seeds, Devgen Seeds, Nirmal Seeds, ProAgro Seeds (Bayer BioSciences), New Nandi Seeds, Pioneer Overseas Corporation, Advanta India Seeds, Vibha Seeds, Sagarlaxmi Seeds, Tata Metahelix Seeds, Panchaganga Seeds, Kaveri Seeds, Zuari Seeds, Varun Seeds, Mahodaya Seeds, Rajiv Biogene Seeds, etc., have joined the race and brought out a number of hybrid cultivars with desirable characteristics and are competing in the market. Public research organizations such as AICPMIP, Pune; NARP, Aurangabad; MPKV, Rahuri; Millets Research Station (MRS), Jamnagar; MPKV, Dhule; NARP, Parbhani; and others along with seed corporations such as Mahabeej are also developing and releasing or marketing the hybrids/varieties to reach different niche areas. Many of them have depended on the germplasm and parental lines from ICRISAT. Till 1999, the arrangement was through informal collaboration, and since 2000, many of the private seed companies have joined the Hybrid Parents Research Consortium (HPRC) of ICRISAT. HPRC-I (PM) study brought out that the member

companies developed and marketed several new hybrids during the decade 2000-10. All the new hybrids developed by current HPRC members are listed in Table 3.2. Similarly, the list of hybrids developed by previous HPRC members during the same period (2000-2010) is furnished in Table 3.3. These hybrids and improved varieties present a wide choice to the farmers growing pearl millet to choose from. They differ in duration, yield potential, harvest index, disease resistance, and grain and fodder quality. Many of them are being marketed in the states of Gujarat, Rajasthan, Uttar Pradesh and Maharashtra.

Table 3.1. Historical development of pearl millet cultivars and hybrids in India.

Variety/Hybrid	Pedigree	Release Year	Released by
N 28-15-1	A selection from local bajra	1934	-
Kopargaon local	A selection from local variety	1934	-
Avsari	A selection from local variety	1934	-
HB 3	Tift 23A X J 104	1968	AICPMIP MRS, Jamnagar
BJ104	5141 X J104	1977	IARI, New Delhi
NHB 5	5071A X K559-85	1975	IARI, New Delhi
PHB 10 (HB 6)	PB111A X PIB 155	1975	PAU, Ludhiana
PHB 14 (HB 7)	PB111A X PIB 228	1975	PAU, Ludhiana
AMP 2	-	1981	NARP, Aurangabad
Pusa 763	5141A X D 763	1982	IARI, New Delhi
MBH 110	MS 2 X Pollinator NO.2	1982	Mahyco, Jalna
HHB 45	MS 5141A X H90/4	1984	CCS HAU, Hisar
MBH 118	2A X Pollinator No.3	1985	Mahyco, Jalna
Sangam	Developed by selection in F2 and F3 segregated material received from ICRISAT	1986	AICPMIP MPKV, Rahuri
MBH 130	2A X Pollinator No.4	1986	Mahyco, Jalna
MH 179	81A X ICMP 451	1986	ICRISAT, Hyderabad
MH 180	834A X ICMP 501	1986	ICRISAT, Hyderabad
MH 182	732A X PNBM 83099	1986	AICPMIP, Pune
ICTP 8203	Bred from 5 selected progenies of a landrace from Togo	1988	ICRISAT, Hyderabad
MBH 136	2 AX PL NO.6	1989	Mahyco, Jalna
MBH 149	4A X PL NO.13	1989	Mahyco, Jalna
VBH 4	VBMS -IA X VBR19	1990	Vijaya Seeds, Jalna
GHB 181	81A X J2002	1990	AICPMIP MRS, Jamnagar
Eknath 301 (NBH 9)	NBMS 13A X NB 37	1991	Nath Seeds, Aurangabad
MLBH 104 (MH 351)	53A X MI 13	1991	Mahindra Seeds, MH
MBH 160	NMS-9 X PI 21	1993	Mahyco, India
ICMH 356	ICMA 88004 X ICMR 356	1993	ICRISAT, Hyderabad
ICMH- 312	81A X ICMR 312	1993	ICRISAT, Hyderabad
RHRBH 8609 (Sharddha)	RHRBH 1A X RHRBI 138	1994	AICPMIP MPKV, Rahuri
AHB 251 (Devgiri)	81A X AIB 16	1994	NARP, Aurangabad
PABH 3	PAMS 1A X Zim-1	1995	NARP, Aurangabad

Continued

Table 3.1 *Continued*

Variety/Hybrid	Pedigree	Release Year	Released by
Nandi 30	NMS 3A X NMP 13	1995	New Nandi Seed Corporation, Ahmedabad
Mahyco 204 (MRB 204)	-	1995	Mahyco, Jalna
MLBH 267	3A X 153	1996	Mahindra Seeds Limited, Jalna
RHRBH 8924 (Saburi)	RHRB 5A X RHBI 458	1997	AICPMIP MPKV, Rahuri
PAC 903 (ICI 903)	Private company	1997	ITC Zeneca Limited, Bangalore
GK 1004	GKPM 1A X GKPM 59R	1997	Ganga Agri Seeds Ltd., Hyderabad
AIMP 92901 (Samrudhi)	Bred by random mating 272 S1 progenies from C5 cycle of bold seeded early composite	1998	AICPMIP RRS NARP, Aurangabad, Maharashtra
MLBH 308	-	1998	Devgen Seeds
MLBH 504 (Dev Gen)	36A X MI-67	1998	Devgen Seeds
MLBH 44 (MLBH 505, MH 793)	MS40A X MI70	1999	Mahindra Hybrid Seed Corporation, Jalna
Nirmal 9	-	2000	Nirmal Seeds
Proagro 9330	-	2000	Proagro Seeds
Nandi 35	NMS 11A X NMP 42	2001	New Nandi, Ahmedabad
Pioneer 86 M 32	-	2002	Pioneer Hybrid Seeds
Nirmal 40	-	2002	Nirmal Seeds
PPC 6 (Parbhanisampada)		2005	AICPMIP, RRS, NARP Parbhani
Sagar 205		2005	Sagarlaxmi-MH
B 2301 (B -2301)	B 0009A X B 5103R	2007	Zuari Seeds Ltd, Bangalore
Kaveri Super Boss	-	2007	Kaveri Seeds
PB 727 (Proagro 9555)	PSP 51 X PP 38	2008	Bayer BioScience, Hyderabad
MH 1351 (Sagar Urmi)	pedigree not available (private company)	2008	Sagarlaxmi (MH)
MH 1352 (Biogene 66)	pedigree not available (private company)	2008	Rajiv bio gene (MH)
GK 1051	PM 678A-II X PM 1081 R-I	2008	Ganga Kaveri, Hyderabad
Poineer 86 M 33	-	2009	Pioneer Hybrid Seeds
Dhaanya 7872	-	2009	TATA Metahelix
RHRBH 9808	RHRB 13A X RHRBI 1314	2010	AICPMIP, MPKV, Dhule
Mahyco 2240 (MRB 2240)	-	2010	Mahyco, Jalna
VBBH 3040	VBBA 310089 X VBBR330585	2011	Vibha Seeds, AP
PAC 909	110057 X 130453	2011	AdvantaIndia Ltd. Secunderabad
86 M 53	M096F X M 119R	2011	Pioneer Overseas Corp., Hyderabad

Continued

Table 3.1. *Continued*

Variety/Hybrid	Pedigree	Release Year	Released by
86 M 64 (MSH 203)	M096F X M 117R	2011	Pioneer Overseas Corp., Hyderabad
Tilak (DB 2013)	-	2011	Dev Gen Seeds
M 1003 (Manik)	-	2013	Mahabeej
GK 1044	-	-	Ganga Kaveri Seeds
Mahyco 163 (MBH 163)	-	-	Mahyco, Jalna
Pancha Ganga 510	-	-	Pancha Ganga Seeds
Varun 666	-	-	Varun Seeds
MDBH 318	-	-	Mahodhaya Seeds
Mahyco 2210 (MRB 2210)	-	-	Mahyco, Jalna

Source: TRIVSA DATABASE, 2012-13 accessed at https://www.asti.cgiar.org/trivsa; Kumara Charyulu et al. 2014

Table 3.2. List of hybrids developed by current private seed company members of HPRC- Pearl Millet of ICRISAT between 2000 and 2010.

		No. of hybrids		No. of years in market		
Seed company (SC) code no.	Total no. of hybrids released	With ICRISAT bred lines	Without ICRISAT bred lines	ICRISAT bred lines	Non-ICRISAT bred lines	% ICRISAT contribution
SC-01	5	5	0	1- 4	-	100
SC-02	9	9*	0	1-10	-	100
SC-03	7	7	0	1-16	-	100
SC-04	5	4	1	1-5	1-4	80
SC-05	4	0	4	-	1-7	0
SC-06	0	0	0	-	-	0
SC-07	4	0	4	-	1-5	0
SC-08	7	7	0	1-6	-	100
SC-09	3	2	1	17-20	-	67
SC-10	6	6	0	4-9	-	100
SC-11	4	2	2	5-8	2-7	50
SC-12	9	9	0	2-13	-	100
SC-13	9	5	4	2-15	2-26	56
SC-14	3	3	0	4-6	-	100
SC-15	8	8	0	-	1-9	-
SC-16	4	0	4	-	2-4	-
SC-17	4	0	4	-	3-6	-
SC-18	3	0	3	-	4	-
SC-19	1	0	1	-	2	-
SC-20	7	2	5	2	2-6	29
SC-21	3	2	1	2-7	1	67
Total	**105**	**71**	**34**	**-**	**-**	**68**

* included on fodder hybrid

Pearl millet hybrids developed using ICRISAT-bred material either by public sector or private seed companies are defined as HPRC hybrids, otherwise they are referred to as NHPRC hybrids in the present study. Further, the seed company (SC) hybrid details and the extent of their involvement with ICRISAT parental lines are highlighted in *Annexure 1*. A unique coding system was followed for each HPRC hybrid produced by different seed companies. Some of the seed companies were members of the HPRC during either first phase (2000-04) or second phase (2005-09) but not during the study period (2014-15). They have accessed and utilized ICRISAT-bred material and developed nine pearl millet hybrids between 2000 and 2010. These previous seed company (PSC) details are also furnished in Table 3.3.

A total of nearly 80 private sector hybrids were developed and released from about 27 private sector seed companies based on ICRISAT source material during 2000-2010. A few of these companies are planning to release a few more hybrids in the next two to three years. The study also noticed nearly 57 NHPRC hybrids cultivated by sampled farmers in the targeted area. The details of these hybrids are furnished in *Annexure 2* of this report. Pusa 23 and HHB 67 were public-bred hybrids (released prior to 2000) quite popular in study regions developed using ICRISAT source material. Due to confidentiality agreement with ICRISAT, the details of HPRC members and respective hybrids developed by them were encoded and presented in the report. The documentation of this information itself clearly reveals the remarkable success of HPRC pearl millet in India.

Table 3.3. List of hybrids developed by previous HPRC members between 2000 and 2010.

Previous seed company (PSC) code	No. of hybrids developed
PSC-01	2
PSC-02	1
PSC-03	1
PSC-04	2
PSC-05	2
PSC-06	1
Total	**9**

The continued impact of HPRC in generating new hybrids using ICRISAT-bred parental lines by private seed companies has been observed. Information about hybrids developed using ICRISAT-bred materials and likely to be released in the next few years was also obtained from respondent HPRC private seed company members. The details of those responses are summarized in Table 3.4.

A total of 56 hybrids (including 41 for rainy season, 3 for post-rainy season and 12 for summer cultivation) were in the pipeline and would likely be made available in the market in next few years. Most of these hybrids were early-to-medium maturing and targeted for Rajasthan, Haryana, Uttar Pradesh, Gujarat and Maharashtra states.

Table 3.5 presents the details about ICRISAT's contribution to the repository of parental lines with HPRC private seed company members during 2000-2010. The extent of receipt of various parental lines (A-, B- and R-lines) during the study period are furnished by company. This clearly reveals significant contribution of ICRISAT pearl millet research in the development of HPRC hybrids and their dissemination in the target ecologies. During 2000-2010, a total of 4515 A-lines were added to the gene banks of 16 private seed (PS) companies, of which 1136 (25%) were shared by ICRISAT. More than 50% or equal contribution to the stock of A/B-lines to 8 companies were made by ICRISAT, which indicates its pivotal role in generating and delivering CMS lines for development of hybrids. Similarly, a total of 4541 B-lines (maintainers of A-lines) were added to the working collection of breeding lines of 16 private sector HPRC members, of which, 1204 (27%) were contributed by ICRISAT. About eight private sector members were significantly (≥ 50%) benefited through supply of B-lines. A total of 9387 R-lines were added to the gene banks of sampled members, out of which 2192 (23%) were added by ICRISAT. Overall, approximately one-fourth of total parental lines (A-, B- and R-lines) were supplied by ICRISAT during the study period to 21 sampled HPRC members.

Table 3.4. HPRC hybrids likely to be released in study states.

Seed company (SC) code no.	No. of hybrids in pipeline		
	Rainy season	Post-rainy season	Summer season
SC-01	3	0	1
SC-02	3	0	0
SC-03	1	0	2
SC-04	3	0	1
SC-05	5***		1
SC-06	3	0	0
SC-07	3	0	1
SC-08	2	0	1
SC-09	1	0	1
SC-10	1	0	2*
SC-11	1**	0	
SC-12	1	0	1
SC-13	2	0	0
SC-14	2	0	0
SC-15	2	0	0
SC-16	1	1	1
SC-17	1	0	0
SC-18	2	0	0
SC-19	2	2***	0
SC-20	0	0	0
SC-21	2	0	0
Total	**41**	**3**	**12**

* One hybrid is common for both rainy and summer seasons
** Common for rainy and summer seasons
*** Common for both rainy and post-rainy seasons

The extent of utilization of parental lines for development of public sector HPRC hybrids were also compiled from five NARS partners. The details of NARS partners are furnished in Table 3.6. Except AICPMIP all the other four NARS centers were actively involved in the development of public sector HPRC hybrids. The pattern of utilization of ICRISAT parental lines by center is furnished in Table 3.6. Further, the list of hybrids developed by NARS partners is presented in *Annexure 3*.

Similarly, the information on number of pearl millet hybrids that were likely to be released in the coming 2-3 years were also collected from respective NARS partners. The summary of those details is furnished in Table 3.7.

Table 3.8 summarizes the details about ICRISAT's contribution of pearl millet parental lines to the growth of different NARS organizations' parental lines through HPRC during 2000-2010. ICRISAT had been contributing many hybrid parental lines through HPRC to the NARS partners over the years. However, this survey has captured the information on the contribution of A-, B- and R-lines to NARS partners during 2000-2010. A total of 1003 A-lines were added to the gene banks of five NARS partners, of which 439 (44%) were contributed by ICRISAT. Similarly, 24% of B-lines and 15% of R-lines were also added to the selected five NARS partners during the study period.

Table 3.5. ICRISAT's contribution to the repository of parental lines with HPRC members during 2000-2010.

Seed company code no.	A/B lines			B-lines			R-lines		
	Total lines	IC-lines	% share	Total lines	IC-lines	% share	Total lines	IC-lines	% share
SC-01	65	55	85	50	44	88	209	150	72
SC-02	160	160	100	207	195	94	481	481	100
SC-03	NA	NA	NA	NA	NA	NA	NA	NA	NA
SC-04	1,014	166	16	1014	201	20	1,703	221	13
SC-05	177	135	76	177	135	76	414	176	43
SC-06	57	13	23	57	7	12	26	17	65
SC-07	125	19	15	142	35	25	134	27	20
SC-08	113	32	28	64	21	33	322	57	18
SC-09	192	83	43	192	83	43	360	144	40
SC-10	NA	NA	NA	NA	NA	NA	NA	NA	NA
SC-11	16	4	25	16	4	25	23	7	30
SC-12	129	89	69	129	89	69	118	78	66
SC-13	NA	NA	NA	NA	NA	NA	NA	NA	NA
SC-14	113	101	89	124	111	90	519	420	81
SC-15	1,954	64	3	1,954	64	3	3,781	38	1
SC-16	16	8	50	16	8	50	25	10	40
SC-17	200	139	70	215	139	65	478	217	45
SC-18	NA	NA	NA	NA	NA	NA	NA	NA	NA
SC-19	2	2	100	2	2	100	29	19	66
SC-20	NA	NA	NA	NA	NA	NA	NA	NA	NA
SC-21	182	66	36	182	66	36	765	130	17
Total	**4,515**	**1,136**	**25**	**4,541**	**1,204**	**27**	**9,387**	**2,192**	**23**

Note: IC-lines stands for ICRISAT parental lines

Table 3.6. Public-bred HPRC hybrid development using ICRISAT parent lines during 2000-2010.

Code no.	Total no. of hybrids developed	No. of hybrids		No. of years in market		% ICRISAT contribution
		With ICRISAT-bred lines	Without ICRISAT-bred lines	HPRC hybrid	Non-HPRC hybrid	
NARS-1	8	7	1	3-8	7	88
NARS-2	8	6	2	2-11	2-7	75
NARS-3	3	0	3	0	5-20	0
NARS-4	6	6	0	1-11	0	100
Total	**25**	**19**	**6**	**2-11**	**2-20**	**66**

NARS-1: Pearl millet Research Station, Junagadh Agricultural University, Jamnagar, Gujarat
NARS-2: CCS Haryana Agricultural University, Hisar, Haryana
NARS-3: Agricultural Research Station, Mahatma Phule Agricultural University, Dhule, Maharashtra
NARS-4: Agricultural Research Station, Durgapura, SK Rajasthan Agricultural University, Bikaner, Rajasthan and
NARS-5: All India Coordinated Pearl Millet Improvement Project (AICPMIP), Jodhpur, Rajasthan

Table 3.7. Public-bred HPRC hybrids likely to be released in targeted ecologies.

Code no.	No. of hybrids in pipeline	Targeted ecology (rainy season)
NARS-1	2	Zone A of North India
NARS-2	2	Zone A_1 of dry region
NARS-3	1	Zone B
NARS-4	2	Zone A_1 and A
NARS-5	1	Zone A
Total	**8**	

Table 3.8. ICRISAT contribution of parental lines to the growth of different NARS organization partners through HPRC during 2000-2010.

	A-lines			B-lines			R-lines		
Code no.	Total lines	IC-lines	% share	Total lines	IC-lines	% share	Total lines	IC-lines	% share
NARS-1	97	69	71	137	74	54	113	40	35
NARS-2	632	238	38	2,127	408	19	6,067	983	16
NARS-3	90	77	86	90	77	86	149	20	13
NARS-4	135	6	4	145	13	9	394	0	0
NARS-5	49	49	100	49	49	100	122	0	0
Total	**1,003**	**439**	**44**	**2,548**	**621**	**24**	**6,845**	**1,043**	**15**

Note: IC-lines stands for ICRISAT parental lines

3.3 Policy bias against coarse cereals

Technology can provide options to farmers to increase productivity; however, the profitability of a crop is influenced to a considerable extent by the policies of the Government. In general, coarse grains were the staple grains produced and consumed in the rainfed areas of the country. After independence, there was a massive drive to build irrigation projects wherever possible. Since it was decided by the Union and State Governments not to recover the capital costs of these projects from the beneficiaries, demands came from the people of all the regions to build more of these projects.

The lands receiving water from the irrigation projects appreciated in value, reached higher productivity levels and received rents in the form of lease values, all because of public investments that were never recovered from the beneficiaries. In contrast, rainfed lands, on which coarse cereals like pearl millet are grown, never received the benefits of any compensating public investments and remained low productive areas (Rao KPC 2006 and see Box 1). Once the irrigation facilities were developed, the cropping patterns changed from coarse cereals like pearl millet to fine cereals such as rice and wheat.

In case of irrigated areas, marketable surplus was produced in crops such as rice and wheat due to higher and stable yields. The surplus generated was procured and stored by the Food Corporation of India (FCI) and state civil supplies corporations. When the government introduced Public Distribution System (PDS), the rice and wheat procured were distributed at subsidized prices. It became possible to access fine cereals at much lower prices than coarse grains like pearl millet via the PDS. The public distribution system distorted the price ratios in the market and the consumption of coarse grains was substituted by that of fine cereals. The bias was also implicit in the Minimum Support Price (MSP) policy.

In the initial years of price policy, the MSP announced for pearl millet was about the same as that announced for coarse variety of paddy. It continued up to 1982-83. But, the difference between the MSP of coarse variety of paddy and pearl millet kept on widening over the years. They were brought back to

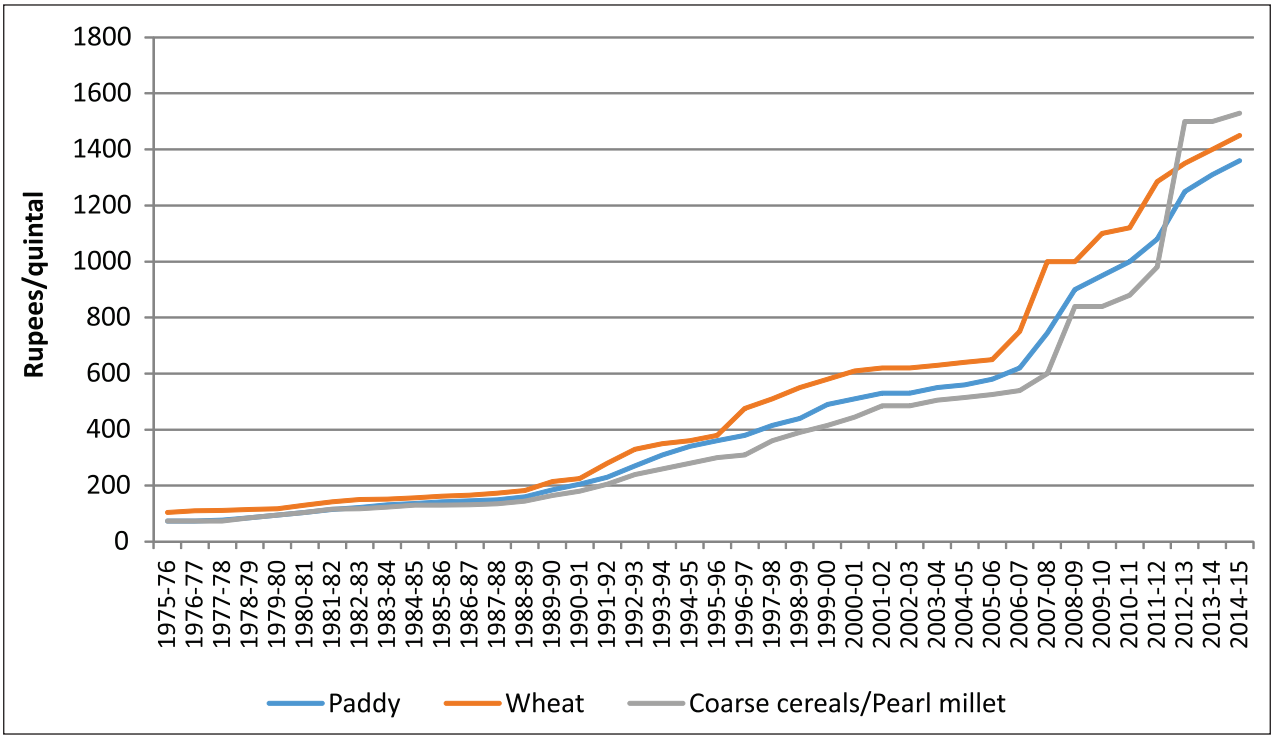
Box 1: A study conducted by KPC Rao (2006) in Andhra Pradesh estimated the levels of input subsidies accessible to the rainfed and irrigated farmers between 1994-95 and 2002-03. The weighted average subsidy received in 1994-95 was ₹1,940 per hectare and it went up to ₹3,578 per hectare in 2002-03. It showed an increase of 84% over the period of 8 years.

In 1994-95, an irrigated hectare in the state received an average subsidy of ₹4,304 as against a mere ₹326 in case of a rainfed hectare. By 2002-03, the gap between them has widened further. In 2002-03, an irrigated hectare received a subsidy of ₹8,566, while a rainfed hectare received only ₹356 as input subsidy. The percentage increase in subsidy per hectare was 99% in case of irrigated agriculture, while it was only 9% in case of rainfed agriculture. The input subsidies received by an irrigated hectare were 13 times that of a rainfed hectare in 1994-95. This ratio has grown to 24 times by 2002-03 on account of a rapid increase in power subsidies.

The study also calculated that nearly 46% of the total subsidies were alone accounted for rice in the state. Cotton and groundnut followed it distantly with their shares at 5% and 4%, respectively. The dryland crops like sorghum, pearl millet and finger millet accounted for less than one percent of the total subsidies.

the same level only in 2012-13. For nearly 30 years, farmers growing pearl millet and other coarse grains were discriminated against by the MSP policy (see Figure 3.1). This was only one part of the story.

Coarse grains such as pearl millet were procured rarely, if at all, by the Food Corporation of India even when the market prices fell below the MSP. On the other hand, procurement of rice and wheat was a routine operation in the surplus states, both when their market prices were above the MSPs and when they fell below the MSP announced. Some reasons were advanced for non-procurement of coarse grains like pearl millet. One reason was that there is no consistent marketable surplus in case of pearl millet, as its production is subject to the vagaries of monsoon. Another reason was that the coarse grains like pearl millet are difficult to store, and deteriorate in quality much faster than rice and wheat. This



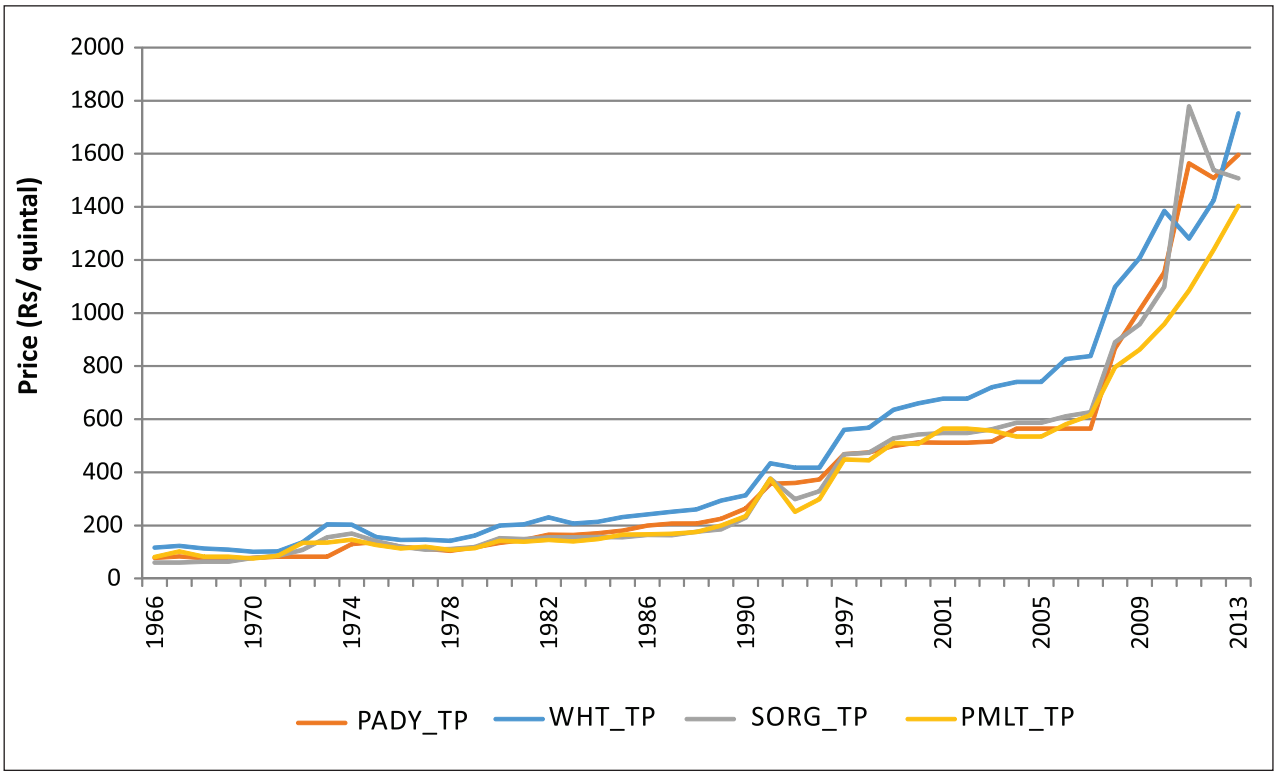
Source: Ministry of Agriculture and Cooperation, 2016

Figure 3.1. Minimum support prices (MSP) of fine and coarse cereals (₹/qtl) in India.

disadvantage could have been offset by research into storage and innovations in processing. Coarse grains were not included in the PDS till 2015, when the National Food Security Mission (NFSM) Act was passed. Theoretically, a consumer can demand coarse grains like pearl millet at ₹ 1 per kg but it is not known whether the government will be able to fulfil this promise as procurement operations are yet to begin in case of coarse cereals such as pearl millet and sorghum.

These policy biases caused by the governments inhibited growth in pearl millet production. In contrast, the production of rice and wheat has increased by several times as these cereals were supported by capital and production subsidies as well as consumption subsidies given to the poor in the PDS. If the capital costs of irrigation projects were fully recovered from the beneficiaries, the profit surplus earned in case of paddy and wheat would have been much lower. In the same way, if rainfed areas received compensating production subsidies at the same level given to the irrigated areas and crops, the reduction in areas under coarse grains would not have been as dramatic as were witnessed during the last four decades. Similarly, if coarse cereals like pearl millet and sorghum were treated at par with rice and wheat in the public distribution system and if they were not discriminated in the fixation of MSP, they would have retained substantial areas under them. Had the coarse cereals received the same kind of procurement support as rice and wheat, pearl millet would not have lost its area as it happened. All these policies have done much more harm to pearl millet farmers than natural calamities like drought and excess rains (see Figure 3.2).

The hard work of pearl millet researchers and farmers would have been recognized much more if there was a balance in the public policies. Normally policy is expected to come to the rescue of the disadvantaged. But, in this case, policies had the opposite effect. They have aided the replacement of coarse cereals by fine cereals.



Source: Department of Agriculture and Cooperation, 2016

Figure 3.2 Farm harvest prices among cereals in Maharashtra (₹/qtl).

3.4 Utilization of pearl millet

3.4.1 Utilization of pearl millet grain

Globally, the availability of millets grew from 26 million tons in 1980-82 to 35 million tons in 2003 but fell back to 28 million tons by 2014-15. . Millets are consumed primarily as food in most of the developing countries. It is a highly nutritious, high-energy food and, in recent years, an important component of processed baby foods. The form in which millets are consumed varies across regions – as a thick porridge, as flat bread (*roti*), etc. Millets are also used as bird feed, but this use is largely restricted to the developed countries. However, their utilization pattern is changing even in developing countries where their use in alcohol manufacture and as livestock and poultry feed is growing. Millet fodder is an important feed resource in the dryland systems of Africa and Asia, particularly in the post-monsoon seasons when other feed resources are not available.

3.4.2 Fodder use

Pearl millet straw is an important feed resource, particularly in India and parts of sub-Saharan Africa. In India, particularly in the arid zone, pearl millet straw is stored and used throughout the year, especially in the summer months when other feed resources are scarce. There is also a growing market for pearl millet straw in urban areas close to the growing centers to meet the increasing demand from urban and peri-urban dairies. Chopped pearl millet straw is commonly traded in urban markets due to its transportability and ease of consumption by animals. Pearl millet dry stover is often sent from Haryana, Punjab and Uttar Pradesh to Rajasthan whenever pearl millet stover is in short supply due to drought. Pearl millet is also exclusively grown as a fodder crop under irrigation in Punjab, Haryana and west Uttar Pradesh.

3.5 Long-term supply and demand elasticity of pearl millet

The literature survey did not find estimates appropriate to pearl millet, both on the supply as well as on the demand side. Kumar P et al. (2011) estimated the income (expenditure) elasticity of food, using QUAIDS (Quadratic Almost Ideal Demand System) model. They estimated the expenditure elasticity of cereals at the aggregate level as 0.187. It was higher at 0.514 for the very poor class; and it decreased to 0.424 for the moderately poor; and further decreased to 0.312 for the non-poor (lower-income) consumers. In case of non-poor (higher-income) consumers, the expenditure elasticity turned negative (-0.095). With the same model, they estimated the uncompensated own price elasticity of cereals as -0.031 for the aggregate group of consumers. The own price elasticity was higher at -0.309 for the very poor group. Its absolute value started falling for the moderately poor (-0.242); to -0.150 for non-poor (lower-income); and to -0.006 for non-poor (higher-income). The inelastic nature of demand for cereals is highlighted by these estimates. When they used the Food Characteristic Demand System (FCDS) model, the income elasticity for coarse cereals was estimated at -0.125 for all consumers. It was -0.123 for very poor group, -0.154 for moderately poor group, -0.141 for non-poor (lower-income), and -0.095 for non-poor (higher-income). Thus, the income elasticity of cereals was found to be positive but decreased with the increase in income. However, in case of coarse cereals, the income elasticity was negative for all income groups, signifying that they are treated as inferior goods by all consumers. Using the same FCDS model, they estimated uncompensated own price elasticity for coarse cereals. These results were in conformity with the results obtained for cereals with QUAIDS model and highlighted the inelastic nature of demand for cereals. The price elasticity of demand was moderate at -0.194 at the aggregate level. The elasticity of demand turned more inelastic with the increase in income level. It was -0.333 for very poor group, -0.281 for moderately poor group, -0.196 for non-poor (lower-income) group and -0.109 for non-poor (higher-income) group.

Ganesh Kumar A et al. (2012) estimated the elasticity of food expenditure for superior cereals in India. The expenditure elasticity was -0.21 for rice and -0.13 for wheat, showing that they are also tending to be inferior goods. They also estimated elasticity for un-irrigated crop acreage model using non-linear Seemingly Unrelated Regression Estimates (SURE). The coefficients were 0.9857 for rice, 1.1359 for wheat

and 1.0704 for maize, but using relative price as their explanatory variable. Correct measures could be obtained by regressing acreage against own price and not against relative price. Due to the paucity of literature with respect to demand and supply elasticity of pearl millet, some realistic assumptions have to be made for making the welfare estimates due to technical change.

3.6 Livestock population in India and study states

Milk production in the country increased quite rapidly in Rajasthan, Gujarat and Uttar Pradesh. The per capita milk availability is 379 g per day per capita in Rajasthan, followed by 300 g in Gujarat and 237 g in Uttar Pradesh in 2000-01. The above states are next only to Punjab and Haryana in terms of per capita milk production and availability. The livestock census data for India illustrate that the livestock numbers increased till 1997 (485 million) but stagnated at that level even in 2003. Cattle population dwindled steadily between 1992 and 2003, while the population of buffaloes, which are reared for milk, showed an increasing trend. As the livestock population stagnates, the requirement for fodder also does not increase, which acts as a dampener on the acreages of sorghum and pearl millet, which are grown by the farmers both for grain and fodder. However, the three study areas of India, North Gujarat, East Rajasthan and West Uttar Pradesh are quite important milk-producing areas with substantial dairy animal population. The demand for pearl millet straw remains quite intact in these areas.

Chapter 4

Sampling framework

Rajasthan, Gujarat and Uttar Pradesh are all important pearl millet growing states in India. In general, pearl millet crop is most preferred in harsh climatic regions where rainfall is very scarce and low. Mostly, farmers prefer to grow pearl millet during rainy season (*kharif*). However, in a few locations, farmers with access to irrigation cultivate it during summer season. Overall, private seed companies have clear domination over the public sector in the pearl millet hybrid seed market. Nearly 80% to 90% of the total seed demand in these states is met by the private sector. However, the new improved hybrids have penetrated the market better than the Open Pollinated Varieties (OPVs). In general, an improved hybrid produces nearly 30% to 40% yield advantage over any of the OPVs. The adoption of improved cultivars is at its peak in the three states and it is worthwhile to conduct a comprehensive study to understand the whole process of adoption and impact at the household level. Keeping these objectives in mind, a robust sampling framework was prepared to cover the three targeted states and ten districts.

4.1 Sample design

Data on the combined seed sales of hybrid pearl millet by the private sector members of HPRC during 2013 show that about 1,562 tons of hybrid pearl millet seed was marketed in Rajasthan alone (Table 4.1). The dominance of Rajasthan state is conspicuous in the total seed sales since 2009. Compared to it, hybrid pearl millet seed sales in Uttar Pradesh and Gujarat were 662 and 557 tons, respectively. Haryana occupied the fourth place with a sale of 397 tons. Maharashtra was a distant fifth with a sale of 107 tons of hybrid pearl millet seed sales. It was decided to restrict the comprehensive impact study to the top three states of Rajasthan, Uttar Pradesh and Gujarat. Since Rajasthan accounted for the maximum seed sales, it was decided to allocate 50% of the sample to that state. Since the states in second and third place, Uttar Pradesh and Gujarat, each had less than one-half of the seed sales of Rajasthan, they were assigned 25% weightage each in the sample. Similarly, the extent of diversity (number of hybrids) of seed sales was also significantly higher both in case of Rajasthan and Uttar Pradesh than in the rest of the states.

4.2 Selection of districts

In the first stage, districts were selected based on the quantum of hybrid seed sales in them. In Gujarat, both the pearl millet area and hybrid seed sales are concentrated in North Gujarat districts of Banaskantha, Patan and Mehsana and, hence, they were purposively selected for the study. Five of the

Table 4.1. Total seed quantity of pearl millet hybrids distributed by HPRC partners in different states between 2008 and 2013.

State	No of hybrids	Seed quantity (tons) distributed across years by the PSC partners						Total (tons)
		2013	2012	2011	2010	2009	2008	
Madhya Pradesh	3	35	59	85	90	100	0	369
Maharashtra	15	107	87	47	47	23	13	324
Uttar Pradesh	21	662	469	404	361	226	35	2,157
Gujarat	14	557	633	512	501	497	18	2,718
Rajasthan	21	1,562	1,258	1,119	1,004	1,069	33	6,045
Haryana	16	397	264	417	409	608	15	2,110
Karnataka	2	10	7	10	5	0	0	32
Punjab	1	0.2	0	0	0	0	0	0.2
Total (tons)	**93**	**3,330**	**2,777**	**2,594**	**2,417**	**2,523**	**114**	**13,755**

Source: HPRC Survey

hybrids were marketed by the HPRC members in Banaskantha, followed by four in Mehsana and three in Patan (see Table 4.2). Overall, a total of 14 HPRC hybrids were marketed intensively in Gujarat state.

In Rajasthan, pearl millet area is spread over many districts, although in the west part of the state, rainfall is scarce and growing period is very short. Traditionally, landraces and OPVs are popular in this region. Extra-short duration hybrid, HHB 67 improved, is gaining prominence in some parts of this region. Due to the uncertainty associated with the success of pearl millet crop in this region, private sector hybrids which take 75 to 95 days to mature have not yet gained popularity in the west Rajasthan region. In east Rajasthan region, they have become quite popular due to better rainfall regime and relatively longer growing seasons. All the private sector companies are targeting the markets of Jaipur, Alwar, Sikar, Dausa and Ajmer for selling their hybrid pearl millet seeds (see Table 4.3). In view of these facts, the districts of Jaipur, Dausa, Alwar and Sikar were purposively chosen for the study. Ten hybrids were marketed by HPRC members in Jaipur district, followed by eight in Alwar, five in Sikar and one in Dausa. Overall, a total of 21 HPRC hybrids were marketed intensively in Rajasthan state. Among the three study states, the extent of hybrid diversity was more in Rajasthan and Uttar Pradesh. Relatively, the diversity of improved cultivars was low in case of Gujarat.

In the same way, the private seed companies are also targeting their marketing efforts in Agra, Hathras, Aligarh, Firozabad and Badaun markets in west Uttar Pradesh (see Table 4.4). Keeping the crop area data and seed market data in mind, the districts of Agra, Mahamaya Nagar (Hathras) and Firozabad were selected for the study in west Uttar Pradesh. About 12 hybrids were marketed by HPRC members in Agra, followed by three in Hathras and two in Firozabad districts. In fact, the Agra market caters to all the three study districts because of its strategic and central location.

4.3 Selection of tehsils, villages and farmers for study

4.3.1 Selection of tehsils, villages and farmers in North Gujarat

For selecting the tehsils and villages in North Gujarat, the research team held discussions with Dr Raj Nath Singh, Chief Scientist, All India Coordinated Research Project for Dryland Agriculture (AICRPDA), Sardar Krishi Nagar, Gujarat; plant breeders and agronomists of the university working on pearl millet;

Table 4.2. Distribution of HPRC hybrids in different districts of Gujarat.

District	No. of hybrids
Ahmedabad	1
Banaskantha	5
Baroda	3
Bhabhar	2
Deesa	5
Deodar	2
Himmatnagar	1
Jamnagar	1
Mehsana	4
Nadiad	1
Palanpur	4
Patan	3
Prantij	3
Sabarkantha	1
Tharad	3
Vadgam	2
Total in Gujarat	**14**

Table 4.3. Distribution of HPRC hybrids in different districts of Rajasthan.

District	No. of hybrids
Ajmer	1
Alwar	8
Barmer	3
Bharatpur	1
Bharatpur & Dausa	2
Bhinmal	2
Dausa	1
Jaipur	10
Jalore	1
Jhunjhunu	1
Jodhapur	7
Karoli	1
Nagaur	5
Sanchore	1
Sawai Madhopur	1
Sikar	5
Sirohi	1
Sumerpur	1
Total in Rajasthan	**21**

Table 4.4. Distribution of HPRC hybrids in different districts of Uttar Pradesh.

District	**No. of hybrids**
Agra	12
Aligarh	8
Auriya	1
Badaun	2
Barielly	1
Bulandshahar	1
Eglas	2
Etah	1
Etawah	1
Firozabad	2
Ghaziabad	3
Hathras	3
Kanpur	6
Varanasi	3
Total in Uttar Pradesh	**21**

and scientists and technical staff associated with the HOPE project of ICRISAT. Based on the information gathered, Banaskantha district was the top district for pearl millet in Gujarat state accounting for more than 25% of the area. It was decided to allocate 50% of the Gujarat sample to this district. Tharad and Vav tehsils specialize in rainy season pearl millet, while summer pearl millet is important in some other tehsils. So, it was decided to focus the study in Tharad and Vav tehsils, of which Tharad tehsil accounts for the bulk of rainy season pearl millet area. Six villages were chosen randomly from the rainy season pearl millet villages from Tharad tehsil. They were Gagana, Dudhava, Karanpura, Ghesada, Savpura and Jandi. Sample farmers were randomly chosen from the pearl millet growers in the respective villages. In fact, every farmer from these villages has grown pearl millet during the rainy season during 2013-14. Depending on the size of the village and number of pearl millet growers in the selected villages, 12 farmers each were chosen from Dudhava and Karanpura villages, 11 from Gagana and 9 each were chosen from Ghesada, Savpura and Jandi, respectively. Vav tehsil has a smaller area under rainy season pearl millet relative to Tharad tehsil. One village, Malsan, was randomly chosen from the few villages growing rainy season pearl millet and nine farmers were randomly selected from the pearl millet growers in that village. Thus, in all, 71 farmers were chosen from Banaskantha district. From Patan district, two tehsils, Patan and Hariz have large areas under rainy season pearl millet. Two villages were randomly selected from the Patan tehsil, while three villages were selected from Hariz tehsil, which has a larger area under rainy season pearl millet. Vadani and Kamalivada villages were randomly selected from Patan tehsil, while Adiya, Toraipur and Kureja villages were chosen randomly from Hariz tehsil. 10 farmers each were chosen randomly from the rainy season pearl millet growers in Vadani, Kamalivada and Adiya villages. 9 farmers were selected from Toraipur village and 8 sample farmers were included from the rainy season pearl millet growers in Kureja village. Thus, a total sample of 47 was chosen from the five villages drawn from two tehsils of Patan district. In Mehsana district, rainy season pearl millet is largely confined to Becharaji tehsil. Three villages, Barief, Kalari and Ganeshpura, were randomly selected from the villages specializing in rainy season pearl millet in this tehsil. 10 farmers each were randomly selected from Barief and Kalari villages, while 9 sample farmers were selected from Ganeshpura village. Thus, a sample of 29 farmers was chosen from three villages of Becharaji tehsil in Mehsana district.

In all, the Gujarat sample added up to 147 farmers: 71 from seven villages of two tehsils in Banaskantha district, 47 from five villages of two tehsils in Patan district and 29 from three villages from one tehsil of Mehsana district. In the opinion of the expert pearl millet group from AICRPDA, this sample well represented the pearl millet growing areas in the rainy season in North Gujarat. The details of sample in North Gujarat are summarized in Table 4.5.

Table 4.5. Sample details of North Gujarat.

S.No	District	Tehsil	Villages	No. of farmers
1	Banaskantha	Tharad	Gagana	12
			Dudhava	12
			Karanpura	11
			Ghesada	9
			Savpara	9
			Jandi	9
		Vav	Malsan	9
2	Patan	Patan	Vadani	10
			Kamalivada	10
		Hariz	Adiya	10
			Toraipur	9
			Kureja	8
3	Mehsana	Becharaji	Barief	10
			Kalari	10
			Ganeshpura	9
		Total		**147**

4.3.2 Selection of tehsils, villages and farmers in East Rajasthan

With the kind facilitation by Dr BS Kumpawat, Chief Scientist, AICRPDA, Bhilwara, Rajasthan, the research team interacted with Dr Surinder Singh Shekhawat, Professor of Agronomy, Regional Research Station, Durgapura, under Rajasthan Agricultural University, Jobner, and plant breeders and agronomists working on pearl millet. The team also visited and interacted with the staff of Krishi Vigyan Kendras at Nayagama, Alwar; Lalchod, Dausa; and Sikar. The extensive discussions of the research team with the local institutions helped in selecting the sample in East Rajasthan.

Since Jaipur is a large district relative to the other three districts, it was decided to allocate a sample of about 90 farmers to Jaipur district and about 60 each to the other three districts, Alwar, Sikar and Dausa. Five tehsils from Jaipur district, which have large areas of pearl millet, Jhatawara, J. Dudu, Phulera, Chomu and Amer were selected for the study. Two villages each were randomly selected from each of the tehsils of Jhatawara, J. Dudu, Phulera and Chomu. In case of Amer tehsil, three villages were selected to represent it. 22 farmers were selected randomly from Amer tehsil with the breakup of 11 farmers from Mori village, six from Sirsali village and five from Rampura Dabadi village. 20 farmers were selected randomly from Phulera tehsil with the breakup of nine from Khedimlik village and 11 from Mohan-Ka-Bas village. I8 farmers were chosen from Chomu tehsil with the breakup of 10 from Bhopas village and eight from Loharwada village. 15 farmers each were randomly selected from Jhatawara and J. Dudu tehsils. The breakup from Jhatawara tehsil was eight farmers from Saranga-Ka-Bas village and seven farmers from Mahari-Ka-Bas village. From J. Dudu tehsil, eight farmers were selected from Kapadia village and seven farmers from Jewaliyan-Ka-Bas village. Thus, in all, 90 sample farmers were selected from 13 villages belonging to six tehsils of Jaipur district.

Depending on the relative distribution of rainy season pearl millet area in Dausa district, three tehsils, Lalsat, Sikrai and Baswa were chosen. Two villages each were randomly selected from these tehsils. 22 farmers were randomly selected from Lalsat tehsil with the breakup of 12 from Chakchandpur (Nayawas) and 10 from Salempura. 20 farmers were randomly selected from Sikrai tehsil with the breakup of 10 from Bhojpura village and 10 from Reta village. In the same way, 21 were selected from Baswa (Bandikui) tehsil, with the breakup of 11 from Monawas village and 10 from Peechupada Nayaketi village. Thus, a total of 63 farmers were chosen from six villages belonging to three tehsils in Dausa district.

In Sikar district, three tehsils, Danta Ramgarh, Sri Madhopur and Khandela were chosen, as they have large areas under rainy season pearl millet. Because of large variation in the sizes of villages in this district, the number of farmers selected from different villages was different. About one half of the sample was chosen from Danta Ramgarh tehsil. As many as 16 farmers were chosen from the big village of Lamiyan in this tehsil. Eight farmers were chosen from Sitarampura village and five were selected from SriKarsan Nagar village. 20 farmers were randomly selected from three villages in Sri Madhopur tehsil with the breakup of eight from Sargoth village and six each from Jaitusar and Malakali villages. 10 farmers were randomly selected from Baori village of Khandela tehsil. Thus, a total of 59 farmers were chosen from seven villages belonging to three tehsils in Sikar district.

In Alwar district, Behror, Bansur and Tijara tehsils were selected for the study as they are known to have large areas under rainy season pearl millet. From Behror tehsil, two villages were selected randomly and 10 farmers each were chosen randomly from Goonti and Sherpur villages. In the same way, two villages, Chatarpura and Jhagdat Kalan, were chosen randomly from the Bansur tehsil. 10 farmers each were chosen from these two villages randomly. From Tijara tehsil, two villages, Gothra and Kakarali were selected. 11 farmers were chosen randomly for the sample from Gothra village and the remaining nine were selected from Kakarali village. Thus, in all, 60 sample farmers were chosen from six villages belonging to three tehsils in Alwar district. Overall, the sample from East Rajasthan included 272 farmers from 30 villages belonging to 14 tehsils in four districts. The details are summarized in Table 4.6.

Table 4.6. Sample details of East Rajasthan.

S.No	District	Tehsil	Villages	No. of farmers
1	Jaipur	Jhatawara	Sarangaka Bas	8
			Mahari ka Bas	7
		J.Dudu	Kapadia	8
			Jewaliyan ka Bas	7
		Chomu	Bhopas	10
			Loharwada	8
		Phulera	Khedimlik	9
			Mohan ka bas	11
		Amer	Mori	11
			Sirsali	6
			Rampura Dabadi	5
2	Dausa	Lalsat	Chakchandpur	12
			Salempura	10
		Sikrai	Bhojpura	10
			Reta	10
		Baswa	Monawas	11
			Peechupada Nayaketi	10
3	Sikar	Danta Ramgarh	Lamiyan	16
			Sitarampura	8
			Srikarsan nagar	5
		Sri Madhopur	Sargoth	8
			Jaitusar	6
			Malakali	6
		Khandela	Baori	10
4	Alwar	Behror	Goonti	10
			Sherpur	10
		Bansur	Chatarpura	10
			Jhagdat Kalan	10
		Tijara	Gothra	11
			Kakarali	9
		Total		**272**

4.3.3 Selection of tehsils, villages and farmers in West Uttar Pradesh

The research team enlisted the support of Dr Surendra Pal Singh, Chief Scientist of AICRPDA, Agra center located at BR College, Agra and his team of scientists and technical personnel. It also benefited from the interactions with the Krishi Vigyan Kendras at Bichpuri, Firozabad and Hathras. Dr Satyendra Pal Singh, I/C of Cost of Cultivation scheme at Agra with the responsibility for Uttar Pradesh and Uttarakhand, also assisted in the selection of villages and sample farmers and in the conduct of the survey. Since the rainy season pearl millet area is equally spread over the three districts, it was decided to split the sample evenly between the three districts of Agra, Firozabad and Hathras (Mahamaya Nagar).

Two tehsils, Kheragarh and Kiraoli, were selected from Agra district as they have large areas of rainy season pearl millet in the district. Two villages, N. Dulhe Khan and Basai Kheragarh, were randomly selected from Kheragarh tehsil. 12 farmers each were selected from these two villages. In the same way, two villages, Dabar and Laldar Ka Nagla, were randomly drawn from Kiraoli tehsil. 12 farmers from Dabar village and 12 farmers from Laldar Ka Nagla were selected for the sample. Thus, a total of 48 sample farmers were selected from four villages belonging to two tehsils in Agra district.

The same sampling strategy was followed in other districts as well. In Firozabad district, Tudla and Shikohabad tehsils, which have large concentration of pearl millet area in the rainy season were chosen. Kheria Jherki and Katiki villages were selected from Tudla tehsil. 11 farmers were selected from Kheria Jherki village, while 13 were chosen randomly from the larger village of Katiki. In the same way, Mandlai and Khitli Syar Mav villages were selected from Shikohabad tehsil. 12 farmers were selected from Mandlai village and 12 from Khitli syar Mav village. Thus, a total of 48 sample farmers were chosen from four villages belonging to two tehsils in Firozabad district.

In Mahamaya Nagar district, two tehsils, Sadabad and Sasani tehsils were chosen randomly to represent rainy season pearl millet areas. Two villages, Bahardoi and Bedai, were selected randomly from Sadabad tehsil. 12 farmers from Bahardoi and 12 farmers from Bedai were chosen randomly to represent the farmers growing pearl millet in the rainy season. In the same way, Chhonda and Jiroli villages were selected randomly from Sasani tehsil. 12 farmers were chosen from each of these two villages. Thus, a total sample of 48 farmers was chosen from four villages belonging to two tehsils in Mahamaya Nagar district. In all, 144 farmers were chosen from 12 villages belonging to six tehsils of three districts from West Uttar Pradesh. The details are summarized and presented in Table 4.7.

Thus, the total size of the sample added up to 563 from 57 villages belonging to 25 tehsils of 10 districts from three states. The location of the sample villages in Gujarat, Rajasthan and Uttar Pradesh is depicted in Figure 4.1.

Table 4.7. Sample details of West Uttar Pradesh.

S.No	District	Tehsil	Villages	No. of farmers
1	Agra	Kheragarh	N.Dulhe khan	12
			Basai Kheragarh	12
		Kiraoli	Dabar	12
			Laldar Ka Nagla	12
2	Firozabad	Tudla	Kheria Jherki	11
			Katiki	13
		Shikohabad	Mandlai	12
			Khitli Syar Mav	12
3	Mahamaya Nagar	Sadabad	Bahardoi	12
			Bedai	12
		Sasani	Chhonda	12
			Jiroli	12
		Total		**144**

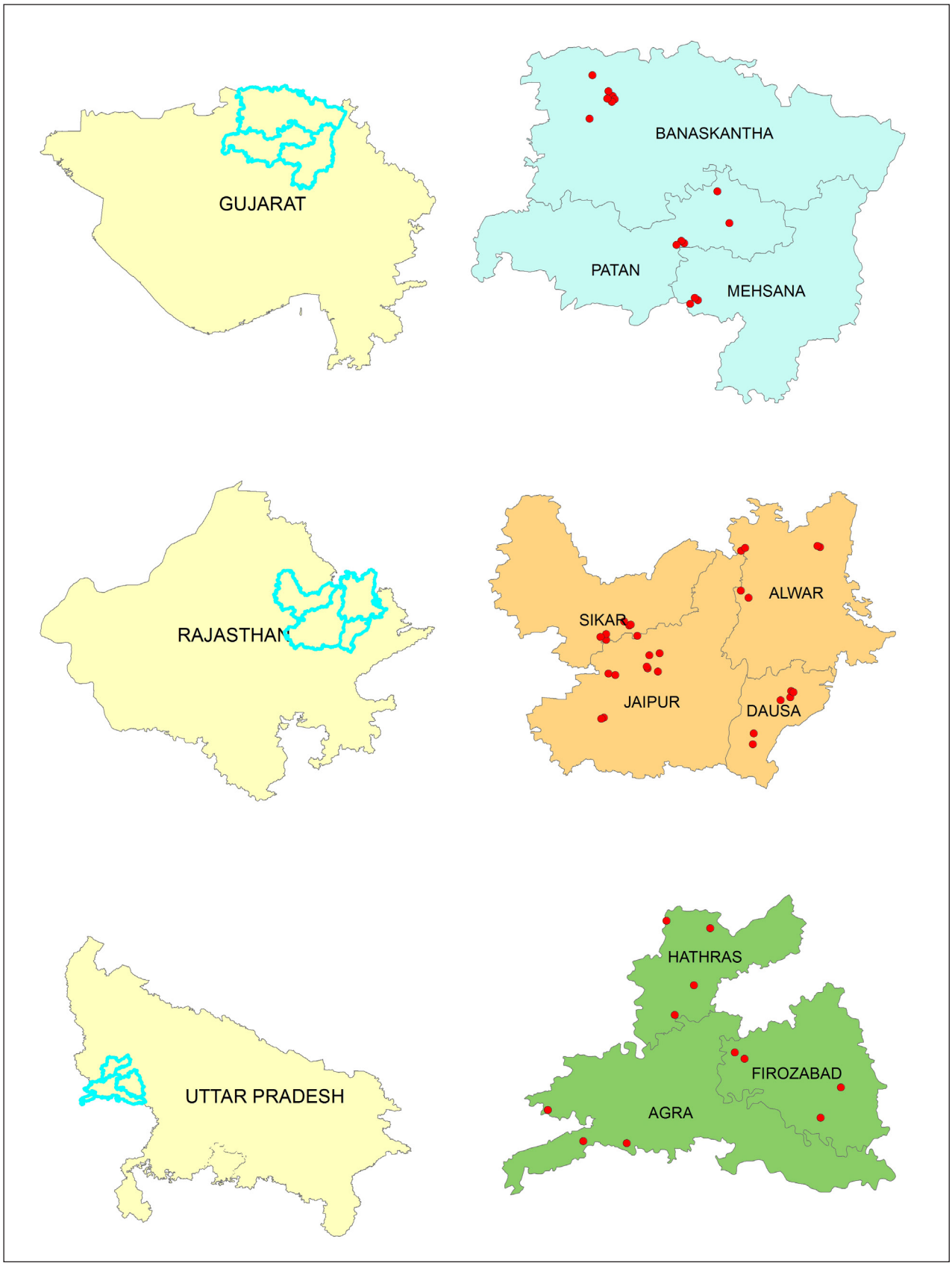


Fig. 4.1. Maps showing the study villages across three states.

Chapter 5

Household survey details and methodology

In order to further enhance the utility of the field survey, the survey team carried out a field-level reconnaissance survey to zero in on the hybrids and cultivars of pearl millet on which the survey has to be focused.

5.1 Field reconnaissance survey

The research team visited all the districts, most of the tehsils and some of the villages and interacted with several farmers growing pearl millet in the rainy season. The items discussed included the timeline of the hybrids introduced, their performance and the production problems encountered by the farmers. The research team also interacted with the seed shop owners and discussed with them the popularity of pearl millet hybrids in different areas, the distribution system and the complaints regarding germination, purity and market acceptance of different hybrids.

5.2 Development of survey instruments and pre-testing

After the reconnaissance survey, the survey team decided to classify the hybrids/varieties popular with the farmers into those that were developed with the parent materials supplied by HPRC and those developed and marketed by companies that are not members of HPRC. The survey team wanted to capture the yield gains and cost reductions that could be attributed to the hybrids developed by using the parent materials supplied by HPRC.

The survey team then designed survey instruments to be used at the household level. After receiving feedback from scientists and field testing, the team finalized the survey instruments. The household survey instruments are furnished in *Annexure 4*.

5.3 Training program for field survey team

At all the three locations, Sardar Krishi Nagar (Gujarat), Durgapura (Rajasthan) and Bichpuri (Uttar Pradesh), the investigators and supervisors were given a detailed overview of the questions in the questionnaires. After the training, two days were spent on pre-testing the questionnaires. This was done to ensure that the investigators were able to understand and put across the questions to the farmers with ease. If they found that some questions were ambiguous and were not able to elicit proper responses from the farmers, they were marked out, and the survey team rephrased them. This refinement process continued till the survey team and investigators felt comfortable with the questions and the responses they were eliciting.

5.4 Household data collection

The survey group carried out the data collection work over a two-month period. The survey work was carried out from 15 January to 10 February 2014 in Gujarat. The survey work was carried out in Rajasthan from 30 January to 27 February 2014. It was implemented in Uttar Pradesh from 14 February to 18 March 2014. Logistic support was provided to the supervisor and investigators for easy movement, accommodation and boarding. Wherever possible, the support of the local agricultural staff and KVK staff was enlisted to clear the apprehensions and inhibitions of the respondents. Data were collected from a total of 563 sample farmers. Most of them were administered with input-output (costs-returns) module on prominent crops also. The supervisors supported the investigators by correcting the filled-in questionnaires and by identifying and rectifying the mistakes made in data collection work. As the work progressed, the investigators developed confidence, tact and ability to deal with the farmers.

5.5 Data validation and verification

The household data were thoroughly cross-checked by the field supervisors during the survey itself. The research team also subsequently checked each questionnaire for data validation. There were differences with the units of reporting landholdings by the respondent farmers. In North Gujarat, farmers were reporting in terms of acres (0.405 hectare). In East Rajasthan, the land units were in terms of both Katcha bigha (1/10 of hectare) and Pakka bigha (1/5 of hectare). In West Uttar Pradesh, the land units used were Katcha bigha (1/8 of hectare) and Pakka bigha (1/4 of hectare). All the responses were checked for consistency before converting them in hectares. All outliers were critically examined and rectified wherever justified.

5.6 Methods of analysis

A detailed data entry format was developed in Microsoft Excel and the data were entered and cross-checked. The data were analyzed section-wise and appropriate tables were generated. Standard farm management concepts used by the Cost of Cultivation Scheme administered by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, were adopted in the analysis of data to generate meaningful comparisons and conclusions.

5.6.1 Comparison between HPRC hybrids and hybrids replaced by them

The performance and profitability of hybrids that were developed using HPRC parent materials were compared and contrasted with those hybrids that were replaced by them. The process of replacement by the HPRC hybrids is quite dynamic. In the first stage, local varieties were replaced by the hybrids. This phase was largely completed before 2005, although some farmers still persist with local varieties in small areas. Some of the hybrids were developed using HPRC materials while others were developed without using them. These two sets of hybrids are competing in the market for gaining market share. Although the HPRC hybrids gained area share gradually, it was not a one-way process. Farmers replaced non-HPRC hybrids with the HPRC hybrids and *vice versa* also. One HPRC hybrid was replaced with another HPRC hybrid and one non-HPRC hybrid was replaced with another one of the same category.

In this dynamic situation, the performance of the current HPRC hybrid was compared with the variety replaced, irrespective of the fact whether the replaced variety was a local one or HPRC hybrid or non-HPRC hybrid. This typically presents the case of before and after comparison.

5.6.2 Comparison between HPRC and non-HPRC hybrids

However, in order to assess the impact of HPRC hybrids, the costs and returns were compared between HPRC hybrids and non-HPRC hybrids. This gives the comparison between with and without situations. This helps establish the advantage of the HPRC hybrids as one group over the group of non-HPRC hybrids. The spread of the hybrids developed with the HPRC parent materials was estimated in the three study states from the sample.

5.6.3 Private and Social benefits

The benefits which accrued to the farmers by growing HPRC hybrids *vis-a-vis* the non-HPRC hybrids are the *private* benefits. Farmers assess the benefits from different HPRC hybrids and non-HPRC hybrids and select the one that suits them best and gives the highest profit. They switch between the HPRC hybrids and non-HPRC hybrids based on their experience and that of the neighboring farmers. While an individual farmer may find a particular HPRC hybrid or non-HPRC hybrid as the most suited to him, the pooled data from the sample for the HPRC hybrids as one group and non-HPRC hybrids as another group are compared to assess the average benefit that HPRC hybrids give over the same from non-HPRC hybrids. These are the *private* benefits.

However, the benefits that accrue to the society, at large, on account of the HPRC hybrids *vis-a-vis* the non-HPRC hybrids are also to be assessed. These are in terms of the unit costs of production from the

HPRC hybrids and non-HPRC hybrids. If the cost of production per quintal of grain from the HPRC hybrids is less than that of the non-HPRC hybrids, it is a benefit to the society. It is a matter of satisfaction for a research organization funded by public institutions. The unit cost reduction multiplied by the quantity of production of the HPRC hybrids in a given area gives the *social* benefits. The *social* benefits are shared between the farmer producers and the consumers, depending on the demand and supply functions for pearl millet in that area. The *social* benefits estimated from the sample are projected to the population based on the proportion of the area under the HPRC hybrids and the total area under the crop in that particular state.

Chapter 6

Results and discussion

The data collected from the sample farmers in the three states of Gujarat, Rajasthan and Uttar Pradesh have been analyzed and the results are presented below.

6.1 General characteristics of sample households

The household heads in the sample typically come from the middle-aged group, with their age averaging around mid-forties. In a relative sense, sample farmers from Gujarat are younger than those in the other two states (Table 6.1). Given the *patriarchal* system of legacy and inheritance, men typically head the sample households. With the exception of nine female-headed households in the entire sample, all the remaining 554 households are headed by males. The sample farmers have two to three decades of experience with farming and their experience with pearl millet was almost as long as that with farming. The average years of education of the household head was about 7.35 years in the sample. The level of education was a shade better in the Gujarat sample when compared with that in Rajasthan. The sample farmers from Uttar Pradesh are less literate than those in the other two states. The average family size was relatively smaller in Gujarat, while it was much higher in the Uttar Pradesh sample, with the Rajasthan sample falling in between them. The sex ratios (female to male) were adverse in all the states, but the Rajasthan sample had a slightly more favorable sex ratio than in the Gujarat and Uttar Pradesh samples. Despite larger family size, the size of family labor force as well as their participation in the labor market was the lowest in Uttar Pradesh. Rajasthan sample had larger family labor force and a higher participation in the labor market than the Gujarat sample. The higher dependency ratio in Uttar Pradesh could be on account of their better asset position and higher household incomes. The participation rates of male members for work on own farms as well as in outside labor market are higher than those for their female counterparts in all the three states.

Table 6.1. General characteristics of sample households.

Item/Districts	Unit	Gujarat (N=147)	Rajasthan (N=272)	Uttar Pradesh (N=144)
Years of farming	Years	23	32	30
Years of pearl millet farming	Years	21	27	29
Household head (no.)	Male	144	267	143
	Female	3	5	1
Average age of household head	Years	44	48	47
Education (years completed)	Years	8.06	7.51	6.49
Average size of family*	No.	5.63	7.56	8.83
No. of male*	No.	3.07	3.94	4.78
No. of female*	No.	2.55	3.62	4.05
No. of family labor (no.)	Male	2.66	2.58	2.51
	Female	1.86	2.36	0.84
	Total	4.52	4.94	3.35
Participation in labor market (no.)	Male	1.1	1.2	0.8
	Female	0.6	0.9	0.3
	Total	**1.7**	**2.1**	**1.1**

*includes children

6.2 Occupational structure of sample households

The main occupation was mostly farming for all the households in the three states, with a few exceptions who considered livestock rearing as their main source of income (Table 6.2). Livestock rearing was the major secondary occupation for the sample farmers in the three states. Only a few farmers could bank on non-farm labor, salary employment and rental income for supplementing their incomes. Forward communities (OC) constituted more than one-half of the sample in Gujarat and Uttar Pradesh. But, in Rajasthan, their share was a mere 14%. Other backward castes (OBC) dominated the Rajasthan sample, with a two-third share. Other weaker groups like socially backward castes (SBC), scheduled castes (SC), scheduled tribes (ST) and nomadic tribes (NT) had very small shares in the sample, reflecting their under-ownership of land. Their combined share in the sample was less than 10%.

Table 6.2. Occupational structure of households in the three study states (no.).

Item	Description	Gujarat (N=147)	Rajasthan (N=272)	Uttar Pradesh (N=144)
Main Occupation	1. Agriculture	145	268	142
	2. Livestock	2	4	2
Secondary Occupation	1. Agriculture	2	2	2
	2. Livestock	140	265	127
	3. Salaried employee	1	1	7
	4. Income from rentals/ business	1	1	2
	5. Non-farm labor	2	2	6
	6. Others	1	1	0
	7. None	0	0	0
Caste category	1. OC	111	38	79
	2. OBC	27	186	50
	3. SBC	1	23	0
	4. SC	7	10	15
	5. ST	1	14	0
	6. NT	0	1	0

6.3 Land holding particulars

The size of landholding was larger in Gujarat than in Rajasthan, while it was the lowest in Uttar Pradesh (Table 6.3). In Gujarat and Rajasthan, leased-in land was far less than the leased-out/fallowed land. As a result, operational holdings were smaller than ownership holdings in these two states. In Uttar Pradesh, sampled farmers had leased-in some land without leasing out or fallowing it. Hence, operational holding was larger in Uttar Pradesh than ownership holding. The irrigated fraction of operational holding was larger in Gujarat and Rajasthan samples, while the converse was the case with the sample in Uttar Pradesh. However, even when the sample farmers have irrigation coverage, they have generally grown pearl millet under rainfed conditions and only provided lifesaving irrigation to it.

6.4 Cropping systems and cropping patterns

Pearl millet is normally grown in poor-to-medium soils. However, the sample farmers in the three states allocated good quality lands to it as it is a staple food to many of the sample farmers. Crops such as cluster bean, green gram, castor, cotton, groundnut, sorghum, etc., compete with it for land in the rainy season. Wheat, mustard, chickpea, potato, barley and vegetable crops are grown in the post-rainy season after pearl millet, wherever irrigation facilities existed.

Table 6.3. Average landholding size of sample (ha per household).

Item	Type	Gujarat (N=147)	Rajasthan (N=272)	Uttar Pradesh (N=144)
Total own land holding	Irrigated	2.46	1.83	0.41
	Rainfed	0.01	0.49	0.96
	Total	2.47	2.32	1.37
Leased-in land	Irrigated	0.00	0.00	0.01
	Rainfed	0.00	0.00	0.05
	Total	0.00	0.00	0.06
Leased out/permanent fallow	Irrigated	0.02	0.13	0.00
	Rainfed	0.00	0.01	0.00
	Total	0.02	0.14	0.00
Operated landholding	Irrigated	2.44	1.70	0.42
	Rainfed	0.01	0.48	1.01
	Total	**2.45**	**2.18**	**1.43**

6.4.1 Cropping pattern in rainy season

Pearl millet was the most important rainy season crop of the sample farmers in all the three study states (Table 6.4). Its share was more than one-third in Gujarat while it was more than one-half in the Rajasthan sample. It occupied the highest share of 70% in the Uttar Pradesh sample. Sorghum, cluster bean and castor were the other important rainy season crops in the Gujarat sample, while cotton, green gram, black gram, pigeonpea, sesame and vegetables were the minor crops. In the Rajasthan sample, cluster bean was the main competing crop, while groundnut, cotton, green gram, castor, sorghum and sesame were the minor crops. Pearl millet was the only major crop in the Uttar Pradesh sample, with sorghum, paddy, cotton, sesame, maize, cluster bean and vegetables occupying minor importance.

Table 6.4. Average rainy season cropping patterns of sample farmers (ha/household).

Crops	Gujarat (N=147)	Rajasthan (N=272)	Uttar Pradesh (N=144)
Pearl millet	0.93	1.19	0.75
Sorghum	0.46	0.01	0.07
Cluster bean	0.38	0.44	0.02
Castor	0.38	0.03	0.00
Cotton	0.13	0.07	0.04
Vegetables	0.02	0.01	0.01
Sesame	0.01	0.01	0.03
Green gram	0.08	0.06	0.02
Pigeonpea	0.01	0.00	0.00
Black gram	0.02	0.00	0.00
Maize	0.0	0.0	0.03
Groundnut	0.0	0.24	0.0
Paddy	0.0	0.0	0.07
Others	0.03	0.01	0.03
Total	**2.45**	**2.07**	**1.07**

6.4.2 Cropping pattern in post-rainy season

Mustard, fennel and wheat were the major post-rainy season crops grown by the sample farmers in Gujarat (Table 6.5). Castor, tobacco and other crops also occupied some areas. Wheat, mustard, barley and chickpea were the main post-rainy season crops in case of the Rajasthan sample, with some other crops having minor areas under them. Wheat, potato and mustard occupied major areas during the post-rainy season in case of Uttar Pradesh, with chickpea and other minor crops covering small areas under them.

Table 6.5. Average post-rainy season cropping pattern of sample farmers (ha/household).

Crops	Gujarat (N=147)	Rajasthan (N=272)	Uttar Pradesh (N=144)
Mustard	0.83	0.57	0.24
Castor	0.27	0.0	0.10
Wheat	0.45	0.81	0.56
Tobacco	0.03	0.0	0.0
Fennel	0.51	0.0	0.0
Barley	0.0	0.28	0.0
Chickpea	0.0	0.2	0.05
Potato	0.0	0.0	0.30
Others	0.07	0.04	0.04
Total	**2.16**	**1.90**	**1.29**

6.4.3 Crops in the summer season

In Gujarat, the sample farmers raised summer crops in 0.64 ha area. Of this, 0.63 hectares was allocated to summer pearl millet, while other crops were grown in the remaining 0.01 ha. In Rajasthan, the sample farmers grew muskmelon in 0.05 ha during summer. A small area of 0.06 ha is cropped during summer by the sample farmers in Uttar Pradesh. One-half of the area (0.03 ha) was under summer pearl millet while the remaining 0.03 ha was shared equally by sorghum, maize and green gram.

The total cropped area in the two main seasons added up to 4.61 ha in Gujarat (Table 6.5). Pearl millet occupied about one-fifth of that area and it was the chief source of grain to the farmers, while its fodder was the chief source of sustenance to their livestock. In the Rajasthan sample, the total cropped area in the two main seasons summed up to 3.97 ha and pearl millet accounted for 30% of it. It was the staple food crop to the farmers and its fodder was quite valuable to the sample farmers to support their livestock. The Uttar Pradesh sample had a combined cropped area of 2.55 ha in the two main seasons. Post-rainy season crops in Uttar Pradesh covered a larger area than the rainy season crops, unlike the samples from Gujarat and Rajasthan. Pearl millet still accounted for about 30% area in the total cropped area, retaining its primacy as grain and fodder supplier to the farmers. These data suggest that pearl millet is quite important to the sampled farmers in all the three states.

6.5 Importance of pearl millet on the sample farms

Table 6.6 furnishes the details of importance of pearl millet in their farms across three study states. Both rainy and post-rainy crops are important in the three study locations. The share of pearl millet cropped area in the total rainy season was quite prominent in case of Uttar Pradesh. It was followed by Rajasthan and Gujarat states, respectively. Similarly, the share of pearl millet cropped area in the total cropped area was higher in case of Rajasthan followed by Uttar Pradesh and Gujarat.

Table 6.6. Importance of pearl millet in sample households (ha/household).

Item	Gujarat (N=147)	Rajasthan (N=272)	Uttar Pradesh (N=144)
Total cropped area	4.61	3.97	2.55
Area under rainy season crops	2.45	2.07	1.07
Area under post-rainy season crops	2.16	1.90	1.48
Pearl millet cropped area	0.93	1.19	0.75
% of pearl millet in rainy season area	37.96	57.49	70.07
% of pearl millet in total cropped area	20.17	29.97	29.41

6.6 Pattern of first adoption of hybrids by the sample farmers

Having established that pearl millet was an important crop to the sample farmers in all the three states of Gujarat, Rajasthan and Uttar Pradesh, we now turn our attention to the important hybrids/cultivars of pearl millet grown by them.

6.6.1 Pattern of first adoption of hybrids by the sample farmers of Gujarat

Table 6.7 gives the first adoption pattern of important pearl millet hybrids in Gujarat sample. Among all, SC-10-hyb 6 was first adopted by the sampled farmers in 2002, but its first adoption peaked in 2005. However, it gradually lost its prominence over the years and only 69 sampled farmers out of 147 (nearly 47%) have adopted it cumulatively. SC-12-hyb 3 was first marketed in 2004, but it quickly attained peak level of first adoption in 2007. Overall, it was the most popular variety, with nearly 62% of the farmers having adopted it in some year or the other. Two other new varieties, SC-04-hyb 2 and SC-18-hyb 1 entered the market in 2008 and they quickly attained the peak levels of adoption in 2012. But they are also losing popularity as new hybrids are put in the market by the HPRC members. The other prominent cultivars observed are PSC-01-hyb 1, PSC-01-hyb 2 and NHPRC 38. Their first adoption patterns are also illustrated in Table 6.7. PSC-01-hyb 1 was in the market since 2001, while PSC-01-hyb 2 joined it in 2002. PSC-01-hyb 1 reached the peak of first adoption in 2005, while PSC-01-hyb 2 attained it in 2006. The cumulative adoption rates of these two hybrids are also quite high, with one-half of sampled farmers adopting each of them in some year or the other. NHPRC 38 was first adopted in 2001, but it was confined to some pockets of Gujarat. It attained small peaks in 2003, 2010 and 2012 but did not become very

Table 6.7. First adoption pattern of pearl millet hybrids in Gujarat (N=147).

Year	SC-12-hyb 3	SC-10-hyb 6	SC-04-hyb 2	SC-18-hyb 1	PSC-01-hyb 1	PSC-01-hyb 2	NHPRC 38
2001					2		2
2002		1			2	2	1
2003		1			5	5	5
2004	5	12			8	7	1
2005	9	17			14	9	2
2006	15	12			11	13	2
2007	21	9			9	12	3
2008	14	6	4	3	5	8	2
2009	11	5	5	5	6	7	2
2010	9	3	8	6	5	5	6
2011	4	2	10	8	2	2	1
2012	2	1	14	13	1	3	5
2013	1	0	8	9	1	1	1
Total	**91**	**69**	**49**	**44**	**71**	**74**	**33**

popular. Yet, it remained in contention and about 22% of the sampled farmers adopted it in some year or the other. In general, a majority of hybrids have taken 4-5 years of adoption lag to reach peak levels of first adoption in the state. All the hybrids also sustained (longevity) for nearly about 9-10 years in the market.

6.6.2 First adoption pattern of pearl millet hybrids by sample farmers in Rajasthan

SC-12-hyb 3, SC-13-hyb 1, SC-04-hyb 1 and SC-15-hyb 5 were the more prominent hybrids that became popular in Rajasthan. PSC-05-hyb 7, NHPRC 55 and NHPRC 41 were other popular cultivars in the study area. The first adoption patterns of these seven hybrids are presented in Table 6.8. SC-12-hyb 3 was first introduced in 2004 and it attained a peak level of adoption in 2010. It is still being adopted by new farmers even in 2013. More than one third of the sampled farmers adopted it in some year or the other. SC-04-hyb 1 and SC-15-hyb 5 were first marketed in 2007. SC-04-hyb 1 attained peak adoption in 2009, while SC-15-hyb 5 reached it in 2011. SC-04-hyb 1 and SC-15-hyb 5 were adopted by 19% and 18% of the sampled farmers in Rajasthan, respectively, in some year or the other. SC-13-hyb 1 was introduced in 2010 but it quickly attained peak level of adoption in 2012. It was also adopted by 17% of the sampled farmers in Rajasthan in different years. Among the non-HPRC hybrids, NHPRC 41 was the first one to be adopted by the sampled farmers in 2002. It reached a small peak in 2007 but remained in contention for long. PSC-05-hyb 7 and NHPRC 55 were both first marketed in 2003. PSC-05-hyb 7 quickly reached peak adoption in 2005 itself, while NHPRC 55 took seven years to attain a peak in 2010. 15% of the sampled farmers adopted PSC-05-hyb 7 in different years. The other two hybrids, NHPRC 55 and NHPRC 41 were adopted by 11% of the sampled farmers each. Most of these hybrids took 3-5 years to reach peak level of first adoption in the state. The longevity of the hybrid ranges between 9 and 10 years.

6.6.3 First adoption pattern of pearl millet hybrids in Uttar Pradesh

Among all the hybrids, SC-03-hyb 7 was the earliest to be introduced in the study region. It attained peak level of adoption in 2005 and remained in contention in some parts of Uttar Pradesh sample villages (Table 6.9). About 47% of the sampled farmers adopted it in one year or the other. SC-12-hyb 3 entered the market in 2004, but it reached peak level of adoption in 2009 and is still attracting new adopters. About 53% of sampled farmers adopted it in one year or the other. NHPRC 08 was first adopted in 2007 and reached peak adoption level in 2010. About 45% of the sampled farmers adopted it in one year or the other. SC-04-hyb 1 was first adopted in 2008 and became popular quickly. It attained peak level of adoption in a matter of two years (2010). Nearly 54% of the sampled farmers adopted it for the first time over the next six years. NHPRC 57 hybrid was introduced in the market in 2001. It scaled a modest peak of

Table 6.8. First adoption pattern of pearl millet hybrids in Rajasthan (N=272).

Year	SC-12-hyb 3	SC-13-hyb 1	SC-04-hyb 1	SC-15-hyb 5	PSC-05-hyb 7	NHPRC 55	NHPRC 41
2002							1
2003					2	2	2
2004	3				3	1	1
2005	6				10	2	2
2006	9				6	3	5
2007	11		8	2	2	4	8
2008	12		10	3	6	3	2
2009	9		14	3	2	4	2
2010	15	5	8	10	5	7	3
2011	8	10	5	17	2	2	1
2012	13	19	4	9	1	1	3
2013	6	13	3	4	1	1	1
Total	**92**	**47**	**52**	**48**	**40**	**30**	**31**

first adoption in 2007 and is still attracting new adopters, but only 26% of the sampled farmers adopted it till 2013. PSC-05-hyb 8 was introduced in 2002 and became popular quickly. It attained peak level of first adoption in 2007 and is still attracting new farmers year after year. Nearly 49% of the sampled farmers used it in different years. NHPRC 49 joined the race in 2003 and reached a modest peak of first adoption in 2010. About 23% of sampled farmers adopted it over the years. Normally, most of the hybrids took 4-6 years to reach peak level of first adoption in the state. The mean longevity of hybrids is perceived around 10-12 years.

Table 6.9. First adoption pattern of pearl millet hybrids in Uttar Pradesh (N=144).

Year	NHPRC 08	SC-04-hyb 01	SC-12-hyb 3	SC-03-hyb 7	PSC-05-hyb 8	NHPRC 57	NHPRC 49
2001				4		2	
2002				4	1	2	
2003				7	2	1	3
2004			6	10	8	1	4
2005			6	13	9	2	2
2006			10	9	12	3	2
2007	6		9	4	15	9	3
2008	9	10	12	3	8	3	2
2009	12	13	14	3	6	4	2
2010	15	27	8	4	5	7	6
2011	10	10	5	2	2	2	5
2012	7	9	4	3	1	1	2
2013	5	8	2	2	1	1	1
Total	**64**	**77**	**76**	**68**	**70**	**38**	**32**

6.7 Sources of information for first year of their introduction

The information about new cultivars in the year of their first adoption was predominantly received from private shops/seed dealers (Table 6.10) in all the three states. In Gujarat, three-fourths of the sampled farmers obtained information from them. Government sources like research center/university, on-farm trials and demonstrations, and extension departments together provided the information to 15% of the sampled farmers. Print and electronic media and NGOs reached the remaining 10% of the sampled farmers. In Rajasthan, 93% of the sampled farmers got information about new hybrids from private seed dealers in the year of their first adoption. Government sources could hardly reach 3%, while other sources provided information to 4% of the farmers. The dependence on private seed dealers was even higher in Uttar Pradesh with 95% of the farmers depending on them. The remaining 5% of the sampled farmers got the information on new hybrids from government institutions in the year of their first adoption.

Table 6.10. Major sources of information for first adoption of improved cultivars (%).

Source of information	Gujarat	Rajasthan	Uttar Pradesh
1. Govt. Extension	1	0	1
2. Farmer Association	0	1	0
3. NGO	1	1	0
4. Research center/Univ.	12	1	0
5. On-farm trials/demos	2	2	4
6. Fellow farmer	7	1	0
7. Private shop/Seed dealer	74	93	95
8. Newspaper/radio/TV	3	1	0
Total	**100**	**100**	**100**

6.8 Main reasons for growing pearl millet

Table 6.11. Reasons for growing rainy season pearl millet (mean weight out of 100).

Reasons	Gujarat (N=147)	Rajasthan (N=272)	Uttar Pradesh (N=144)
Crop rotation	1	1	10
Fodder purpose	47	48	32
Grain purpose	52	50	58
Suitable to soil and climate	0	1	0

The sampled farmers were asked to indicate the primary reason for growing pearl millet. The sampled farmers in Gujarat gave a weightage of 52% to the grain purpose, 47% to fodder and 1% weightage for crop rotation requirement (Table 6.11). In Rajasthan, sampled farmers assigned 50% weightage for grain purpose and 48% for fodder purpose. They assigned 1% weightage each to crop rotation and suitability to soil and climate. In Uttar Pradesh, the sampled farmers assigned a greater weightage of 58% for grain purpose and 32% to fodder use. They gave a weightage of 10% to crop rotation requirement. Thus, it is evident that the farmers grow pearl millet both for grain as well as for fodder purpose. Other considerations such as crop rotation requirement and suitability of land received relatively lower weightage in the decisions of the farmers.

6.9 Sources of seeds of the new varieties

6.9.1 Sources of seed during the first year of introduction

An important source of seed supply in the year of first adoption was local traders/agro-dealers (Table 6.12) in all the three states. Sixty-nine percent of the sampled farmers obtained seed from the traders/agro-dealers in Gujarat. Government sources like extension departments and universities supplied hybrid seeds to 14% of the sampled farmers. Eight percent of the farmers accessed them from the local seed producers, while NGOs and farmers' clubs procured and supplied to 9% of the sampled farmers. In Rajasthan, 78% of the sampled farmers procured them from seed dealers, while 12% accessed them from the local seed producers. Two percent obtained them through farmer-to-farmer exchange. Government institutions supplied them to 4%, while farmers' clubs and NGOs mediated to supply them to the remaining 4% of the sampled farmers. In Uttar Pradesh, 95% of the sampled farmers obtained them from the private seed dealers. Seed exchange with other farmers, local seed producers, farmers' clubs and NGOs together could provide the hybrid seeds to only 5% of the sampled farmers.

Table 6.12. Sources of seed for first adoption of pearl millet improved cultivars (%).

Source of seed	Gujarat	Rajasthan	Uttar Pradesh
1. Research PVS/Universities	4	1	0
2. Extension demo plots	4	1	0
3. Farmer club/villagers	2	3	1
4. Local seed producers	8	12	1
5. Local trader or agro-dealers	69	78	95
6. Farmer-to-farmer seed exchange	0	2	2
7. NGOs	7	1	1
8. Government agency	6	2	0
Total	**100**	**100**	**100**

6.9.2 Sources of seed supply in the year 2013-14

Even during the year (2013-14) of reference for the survey, most of the seeds used by the sampled farmers were bought from local traders or seed companies in the three states (Table 6.13). In Gujarat, 79% of the seeds were bought from the local traders or seed companies. About 10% of the seeds were bought from the local seed producers. Government sources provided only 5% of the seeds required by the farmers. The remaining 6% was met by farmers' clubs, NGOs and farmers' own sources.

Table 6.13. Sources of seed during 2013-14 (% of farmers accessing seed).

Source of seed	Gujarat	Rajasthan	Uttar Pradesh
1. Research PVS/University	3	0	0
2. Extension demo plots	0	0	0
3. Farmer club/villagers	1	5	2
4. Bought from local seed producers	10	4	1
5. Bought from local trader or seed companies	79	86	93
6. Farmer to farmer seed exchange (relative, friend, etc.)	2	3	1
7. Provided free by NGOs	1	0	0
8. Provided free by government agency	2	0	0
9. Own seed	2	2	3
10. Subsidized government seed supply	0	0	0
11. Other	0	0	0
Total	**100**	**100**	**100**

In the Rajasthan sample, 86% of the farmers procured seeds from local traders or seed companies. About 5% of them obtained seed from farmers' clubs or local villagers. Four percent of the farmers bought them from the local seed producers, while 3% of them obtained through farmer-to-farmer exchange. Another 2% relied on their own seed. In Uttar Pradesh, 93% of the sampled farmers procured seeds from local traders and seed companies. Three percent of them depended on their own seed, while 2% obtained them from farmers' clubs and other villagers. One percent each accessed the seeds from local seed producers and by way of farmer-to-farmer exchange.

6.10 Area allocation to pearl millet hybrids during 2011-12 to 2013-14

The sample farmers were asked how much area they allocated to different hybrids of pearl millet during 2011-12, 2012-13 and 2013-14. The data collected were analyzed to assess the adoption and popularity of different pearl millet hybrids in the recent years. Subsequently, the adoption data were segregated between HPRC hybrids, non-HPRC hybrids and local varieties across states.

6.10.1 Area allocation to pearl millet hybrids in Gujarat sample

Marginal area was allocated to local varieties by the sampled farmers in Gujarat. Data on the area allocated to different hybrids by the sampled farmers in Gujarat is summarized in Table 6.14.

The dominance of HPRC hybrids was clearly evident from household survey data across three cropping years (2011-2014). PSC-01-hyb 2 (15.0%) and PSC-01-hyb 1 (13.6%) occupied first and second positions in terms of cropped area coverage among sampled farmers. It was followed by SC-12-hyb 3 (10.5%) and SC-10-hyb 6 (8.4%) hybrids. SC-04-hyb 2 and PSC-05-hyb 7 were other major hybrids that occupied significant cropped area in the study villages. All these top hybrids belong to the HPRC and were developed based on ICRISAT-sourced breeding material/germplasm. SC-18-hyb 1, SC-18-hyb 2, SC-18-hyb 3, NHPRC 35 and NHPRC 37 hybrids were other major cultivars observed in the survey and belong to non-HPRC category. Pusa 23 is public-bred hybrid from IARI using ICRISAT-based genetic material. Since this hybrid was

Table 6.14. Allocation of area under major pearl millet cultivars in Gujarat sample.

Variety	Area in 2011-12 (in ha)	Area in 2012-13 (in ha)	Area in 2013-14 (in ha)	Pooled area in ha (% area)
SC-04-hyb 1	1.62	1.21	2.02	4.85 (1.01)
SC-04-hyb 2	5.26	2.83	19.03	27.12 (5.66)
SC-10-hyb 6	14.98	17.81	7.29	40.08 (8.37)
SC-10-hyb 4	0.81	1.21	2.02	4.04 (0.84)
SC-12-hyb 2	8.10	6.07	4.86	19.03 (3.97)
SC-12-hyb 3	18.22	18.22	14.17	50.61 (10.57)
SC-12-hyb 4	0.61	3.44	0.81	4.86 (1.01)
SC-12-hyb 5	2.02	4.05	3.24	9.31 (1.94)
SC-12-hyb 6	0.00	0.81	0.81	1.62 (0.34)
SC-18-hyb 1	6.48	5.26	3.64	15.38 (3.21)
SC-18-hyb 2	9.11	10.12	4.05	23.28 (4.86)
SC-18-hyb 3	4.86	6.48	3.24	14.58 (3.04)
PSC-01-hyb 2	24.29	25.51	22.27	72.07 (15.05)
PSC-01-hyb 1	26.72	23.48	14.98	65.18 (13.61)
Local	8.1	4.45	3.24	15.79 (3.30)
SC-20-hyb 02	2.43	4.45	4.45	11.33 (2.37)
NHPRC 35	6.88	6.07	2.43	15.38 (3.21)
NHPRC 36	2.43	2.83	0.81	6.07 (1.27)
PSC-02-hyb 3	1.21	1.21	2.43	4.85 (1.01)
NHPRC 37	6.48	5.67	7.69	19.84 (4.14)
PSC-03-hyb 4	1.62	2.83	2.02	6.47 (1.35)
NHPRC 38	2.83	4.05	3.24	10.12 (2.11)
NHPRC 39	2.43	1.21	3.85	7.49 (1.56)
PSC-05-hyb 7	8.91	13.77	0	22.68 (4.74)
PSC-05-hyb 8	0	0.41	2.43	2.84 (0.59)
NHPRC 40	2.43	0	1.62	4.05 (0.85)
Grand total	**168.83**	**173.45**	**136.64**	**478.92 (100.0)**

Note: Figures in the parentheses indicate parentage to column total

released before 2000, it was not considered under the HPRC category. Overall, nearly three-fourth of cropped area (75%) was covered with HPRC hybrids and the remaining one-fourth is dominated by non-HPRC hybrids in Gujarat state.

6.10.2 Area allocation to pearl millet hybrids in Rajasthan sample

The details of area allocation of sampled farmers under pearl millet hybrids in Rajasthan are summarized in Table 6.15. Both HPRC and non-HPRC cultivars were prevalent and occupied almost equal amount of cropped area in sample villages. Among HPRC hybrids, SC-12-hyb 2, SC-12-hyb 3 and SC-12-hyb 5 occupied first, second and third positions, respectively. It was followed by SC-13-hyb 1, SC-10-hyb 6 and SC-04-hyb 1 hybrids preferred by sampled farmers. SC-15-hyb 5 and PSC-05-hyb 7 cultivars were also liked by sampled farmers in the study villages/tehsils. In case of non-HPRC hybrids, a lot of diversity was observed among choices of farmers from village to village. NHPRC 55, NHPRC 41 and NHPRC 44 were a few prominent non-HPRC cultivars highlighted by sampled farmers during the personal interviews. Nearly one-third of

Table 6.15. Allocation of area under major pearl millet cultivars in Rajasthan sample.

Variety	Area in 2011-12 (in ha)	Area in 2012-13 (in ha)	Area in 2013-14 (in ha)	Pooled area in ha (%)
SC-12-hyb 2	29.85	31.75	32.80	94.4 (9.76)
SC-12-hyb 3	28.00	29.00	30.00	87 (8.99)
SC-12-hyb 5	22.35	21.58	22.25	66.18 (6.84)
SC-10-hyb 6	10.40	10.15	10.65	31.2 (3.23)
SC-04-hyb 1	9.50	9.00	10.80	29.3 (3.03)
SC-15-hyb 5	12.15	17.45	13.40	43 (4.45)
SC-15-hyb 1	5.10	5.10	5.30	15.5 (1.60)
SC-03-hyb 7	0.50	0.50	0.50	1.5 (0.16)
SC-13-hyb 1	22.10	21.20	23.50	66.8 (6.91)
SC-04-hyb 2	2.65	2.70	3.30	8.65 (0.89)
PSC-05-hyb 7	6	3.9	5.6	15.5 (1.60)
NHPRC 55	10.05	11.25	4.3	25.6 (2.65)
NHPRC 41	10	10	10	30 (3.10)
NHPRC 43	3.5	5.75	4.1	13.35 (1.38)
NHPRC-45	4.95	5.1	4.65	14.7 (1.52)
NHPRC-44	6.81	6.68	6.17	19.66 (2.03)
Other hybrids	105.35	121.55	113	339.9 (35.14)
Local	22.1	20.6	22.4	65.1 (6.73)
Grand Total	**311.36**	**333.26**	**322.72**	**967.34 (100.0)**

Note: Figures in the parentheses indicate parentage to column total

cropped area was occupied by other private seed company hybrids. WCC 75 and HHB 67 were old cultivars (released before 2000) developed based on ICRISAT source material and still preferred by a few farmers in the state. However, these were not considered in the HPRC coverage adoption estimates. Overall, about half of the total cropped area is covered with HPRC hybrids.

6.10.3 Area allocation to pearl millet hybrids in Uttar Pradesh sample

The data on areas allocated to different hybrids in Uttar Pradesh sample are summarized and presented in Table 6.16. The dominance of HPRC hybrids is clearly noticeable during the survey period in the sample villages/tehsils. About two-thirds of cropped area is covered by HPRC cultivars while the remaining one-third is occupied by non-HPRC cultivars. The area under local cultivars were almost absent in study locations. Among the HPRC hybrids, SC-04-hyb 1 and SC-12-hyb 3 were prominent cultivars preferred by sample farmers in the state. PSC-05-hyb 8 and SC-10-hyb 6 were other dominant cultivars highlighted by sampled farmers during the personal interviews. There is a huge diversity observed in case of non-HPRC cultivar preferences among sampled farmers. Hybrids such as NHPRC 07, NHPRC 08, NHPRC 51, NHPRC 49 and NHPRC 50 were major non-HPRC hybrids identified during the study.

6.10.4 Aggregate picture of area allocation between different cultivars in the three states

The information presented in Tables 6.14 through 6.16 are summarized and presented in Table 6.17 for highlighting the area spread under HPRC and non-HPRC hybrids across study years.

Table 6.17 presents an overview of the spread of HPRC hybrids *vis-a-vis* non-HPRC hybrids and local varieties in the sample. In 2011-12, HPRC hybrids had a share of 56% in the total area under pearl millet

Table 6.16. Allocation of area under major pearl millet hybrids in Uttar Pradesh sample.

Variety	AREA in 2010-11 (in ha)	AREA in 2011-12 (in ha)	AREA in 2012-13 (in ha)	Pooled (in ha)
NHPRC 08	6.08	6.88	9.84	22.8 (8.7)
SC-03-hyb 7	0.88	2.40	0.88	4.16 (1.6)
SC-04-hyb 1	13.52	24.08	51.76	89.36 (34.1)
SC-12-hyb 3	13.04	11.96	14.88	39.88 (15.2)
SC-18-hyb 1	1.12	1.44	1.60	4.16 (1.6)
SC-12-hyb 2	1.12	1.52	3.00	5.64 (2.2)
SC-10-hyb 6	0.96	0.96	2.24	4.16 (1.6)
NHPRC 07	0.64	1.84	1.68	4.16 (1.6)
NHPRC 47	1.04	3.12	4.78	8.94 (3.4)
NHPRC 46	0.72	0.96	2.12	3.8 (1.4)
NHPRC 48	0.4	0.64	1.44	2.48 (0.9)
NHPRC 56	0.24	0.16	0.24	0.64 (0.2)
PSC-05-hyb 8	3.92	5.68	9.12	18.72 (7.1)
NHPRC 41	1.12	0.56	0.88	2.56 (1.0)
NHPRC 51	1.44	2.01	1.68	5.13 (2.0)
NHPRC 49	1.76	4.42	3.28	9.46 (3.6)
NHPRC 50	0	1.12	1.12	2.24 (0.9)
Local	0.48	0.64	0.44	1.56 (0.6)
Other hybrids	10.26	10.62	11.34	32.22 (12.3)
Total	**58.74**	**81.01**	**122.32**	**262.07 (100.0)**

Note: Figures in the parentheses indicates parentage to column total

Table 6.17. Pattern of adoption of HPRC and non-HPRC hybrids in the sample (ha).

Year	Item	Gujarat	Rajasthan	Uttar Pradesh	Pooled
2011-12	HPRC hybrids area	119.63	148.6	33.44	301.67 (56.0)
	Non-HPRC hybrids area	41.1	140.66	24.82	206.58 (38.3)
	Local	8.1	22.1	0.48	30.68 (5.7)
	Total	168.83	311.36	58.74	538.93 (100.0)
2012-13	HPRC hybrids area	131.36	152.33	46.6	330.29 (56.2)
	Non-HPRC hybrids area	37.64	160.33	33.77	231.74 (39.4)
	Local	4.45	20.6	0.64	25.69 (4.4)
	Total	173.45	333.26	81.01	587.72 (100.0)
2013-14	HPRC hybrids area	106.07	158.1	81.88	346.05 (59.5)
	Non-HPRC hybrids area	27.33	142.22	40.0	209.55 (36.0)
	Local	3.24	22.4	0.44	26.08 (4.5)
	Total	**136.64**	**322.72**	**122.32**	**581.68 (100.0)**

Note: Figures in the parenthesis indicates percentages to column total

with the sampled farmers. The local varieties had a share of about 5.7% area and non-HPRC hybrids were on 38.3% of the area. The picture remained more or less the same during 2012-13 also. But, in 2013-14, the share of HPRC hybrids increased close to 60%. With the share of local varieties remaining at 4.5%,

the share of non-HPRC hybrids dropped marginally to 36%. In the pooled data for three years, local varieties have nearly 5% share and the HPRC hybrids and non-HPRC hybrids have shares of 57% and 38%, respectively. Perhaps, it provides an ideal setting to assess the impact of the HPRC hybrids *vis-a-vis* the non-HPRC hybrids in the three sampled states.

6.11 Average productivity levels of pearl millet across states

The productivity levels of pearl millet (grain and fodder) perceived by the sampled farmers were collected during the household survey. The productivity levels recorded during the previous three years were also collected from the farmers by recall method.

Sampled farmers were asked to give their perceptions about the yields of grain and fodder of pearl millet under different weather situations. Under any weather situation – bad, normal or best – the perceived yields were the highest in Uttar Pradesh and the lowest in Gujarat, with Rajasthan giving medium yields (Table 6.18). Perhaps, the differences in soil fertility and rainfall regimes are responsible for this wide variation. In Gujarat, the perceived yields were nine quintals in bad year, 17 quintals in normal year and 25 quintals in the best year. The ratio of fodder to grain was 1.50 in bad and normal years and 1.42 in the best year. In Rajasthan, the grain yield is perceived to be 17 quintals in bad year, 25 quintals in normal year and 31 quintals in best year. The fodder to grain ratio was 1.50 in bad and normal years and 1.40 in the best year. The perceived yields in Uttar Pradesh were 23 quintals per hectare in bad year, 34 quintals in normal year and 43 quintals in best year. The fodder to grain ratio was around 1.40 in any type of year.

The actual yields of grain and fodder of pearl millet reported by the sampled farmers during the three years, 2011-12, 2012-13 and 2013-14, are presented in Table 6.19. Gujarat experienced bad weather conditions in 2011-12 and 2012-13 and normal weather conditions in 2013-14. The grain yield was around 9 quintals per ha in 2011-12, 11 quintals in 2012-13 and 20 quintals per ha in 2013-14. The grain to fodder ratio was about 1.62 in the first two years and 1.48 in the third year. Rajasthan experienced normal weather in the first year and best weather in the next two years. The grain yield was 18 quintals in 2011-12, 30 quintals in 2012-13 and 26 quintals in 2013-14. The grain to fodder ratio was around 1.50 in the first two years and 1.40 in the third year. Uttar Pradesh experienced normal weather in 2011-12 and good weather in the two subsequent years. In Uttar Pradesh, the grain yield was 26 quintals in 2011-12, 41 quintals in 2012-13 and 36 quintals per ha in 2013-14. The fodder to grain ratio was around 1.40 in all the years. This analysis clearly brought out that the survey year (2013-14) is not affected by any weather aberrations across the three states.

Table 6.18. Average pearl millet yields perceived by sampled farmers under different climatic situations (qtl/ha).

	Gujarat		Rajasthan		Uttar Pradesh	
Season type	Grain	Fodder	Grain	Fodder	Grain	Fodder
Bad year	9.06	13.99	16.71	25.26	22.95	32.50
Normal year	16.80	25.30	25.31	37.51	33.95	47.75
Best yield	24.68	35.21	30.80	43.12	43.00	61.80

Table 6.19. Average yields of the sampled farmers during 2011-12 to 2013-14.

	Gujarat		Rajasthan		Uttar Pradesh	
Year	Grain*	Fodder*	Grain*	Fodder*	Grain*	Fodder*
2011-12	9.08	14.77	18.26	28.50	26.45	37.85
2012-13	10.76	17.50	30.12	43.25	40.65	57.50
2013-14	20.35	31.79	25.51	35.69	36.05	50.35

* qtl per ha

6.12 Economics of cultivation of HPRC hybrids vs hybrids replaced by HPRC hybrids, and vs non-HPRC hybrids

The average yields of HPRC hybrids and non-HPRC hybrids are computed from the data collected with the cost of cultivation module and are presented in Table 6.20.

On a sample household in Gujarat, HPRC hybrids were grown in 0.72 ha, while the non-HPRC hybrids were grown in 0.19 ha (Table 6.20). A hectare of HPRC hybrids, on an average, yielded 21.76 quintals of grain and 32.55 quintals of fodder per ha. Similarly, a hectare of non-HPRC hybrids yielded only 18.57 quintals of grain and 30.22 quintals of fodder in Gujarat. In Rajasthan, HPRC hybrids were grown in 0.58 ha, while the non-HPRC hybrids were grown in 0.52 ha. A hectare of HPRC hybrids, on an average, gave 27.28 quintals of grain and 38.7 quintals of fodder. A hectare of non-HPRC hybrids yielded 22.03 quintals of grain and 31 quintals of fodder. In Uttar Pradesh, HPRC hybrids were grown in 0.57 ha, while the non-HPRC hybrids were grown in 0.28 ha. The average yield of HPRC hybrids was 39.35 quintals of grain and 55.4 quintals of fodder per ha. The non-HPRC hybrids gave only 32.78 quintals of grain and 47.7 quintals of fodder per hectare.

Table 6.20. Grain and fodder yields of HPRC hybrids and non-HPRC hybrids (kg/ha), 2013-14.

	HPRC hybrids			Non-HPRC hybrids		
State	Area (ha/hh)	Grain	Fodder	Area (ha/hh)	Grain	Fodder
Gujarat	0.72	2,176	3,255	0.19	1,857	3,022
Rajasthan	0.58	2,728	3,870	0.52	2,203	3,100
Uttar Pradesh	0.57	3,935	5,540	0.28	3,278	4,770

6.12.1 Profitability of the HPRC hybrids *vis-a-vis* the hybrids replaced by them in Gujarat, 2013-14

The relative profitability of the HPRC hybrids in Gujarat sample *vis-a-vis* the hybrids replaced by them is presented in Table 6.21. The variable costs incurred in case of the HPRC hybrids (US$261) per ha were slightly higher than those incurred on the hybrids replaced by them (US$240). The fixed costs were also higher in case of HPRC hybrids by US$14 per ha. Thus, the total cost of production per ha was higher by US$35 per ha when compared with the hybrids replaced by them. But this higher cost of cultivation was more than compensated by the higher yields of grain and fodder achieved by the HPRC hybrids. Their grain yield was higher by 6.98 quintals per ha. The fodder yield of the HPRC hybrids was also higher by 8.33 qtl/ha. The net returns per ha from the HPRC hybrids (US$171) per ha exceeded the returns from the replaced hybrids by US$159, as the benefits from the replaced hybrids just exceeded the costs only by US$12 per ha. The benefit-cost ratio was as high as 1.40 in case of the HPRC hybrids, while the replaced hybrids hardly gave a benefit-cost ratio of 1.03. The unit cost of production was only US$12 per quintal in case of the HPRC hybrids, while it was as high as US$16 per quintal in case of the replaced hybrids. Both the private benefits of the farmers (US$159 per ha) as well as the social benefits (US$4 per quintal of grain produced) were impressively higher. They provided the rationale and economic justification for the replacement of the earlier hybrids by the HPRC hybrids.

6.12.2 Profitability of the HPRC hybrids *vis-a-vis* the non-HPRC hybrids in Gujarat, 2013-14

The cost of cultivation of HPRC hybrids in Gujarat worked out to be US$428 per ha (Table 6.22). The variable costs were lower in case of the HPRC hybrids by US$26 per ha when compared to the non-HPRC hybrids. However, the fixed cost was substantial in their case because of higher rental value of land. The gross returns were US$599 per ha, yielding a net return of US$171 per ha. The benefit-cost ratio worked out to be 1.40. The unit variable cost per quintal of pearl millet was computed as US$12. In case of non-HPRC hybrids, the variable cost was slightly higher because of higher cost of harvesting and threshing. The total cost of cultivation was higher at US$449 per ha. But the gross returns were lower at US$515

per ha due to lower grain and fodder yields. As a result, the net returns per ha were only US$66 and the benefit-cost ratio was only 1.15. The unit variable cost per quintal of grain production worked out to be US$15.45. Thus, the better performance of HPRC hybrids was amply demonstrated by way of higher benefit-cost ratio and lower unit cost of production when compared with the same for non-HPRC hybrids. The farmers benefited to an extent of US$105 per ha by cultivating HPRC hybrids over what they could get from the non-HPRC hybrids. The unit cost reduction of US$3.45 per quintal of pearl millet was the benefit to the society that accrued because of the development of HPRC hybrids. This 22% reduction in unit cost of production helped the farmers to realize higher profits and the consumers to access pearl millet at relatively lower prices in the market.

Table 6.21. Relative performance of HPRC hybrids and the hybrids replaced by them in Gujarat in ₹ (US$)/ha, 2013-14.

Activity	Hybrids with HPRC parents	Hybrids replaced by HPRC hybrids
Land preparation	2,396 (41)	2,155 (37)
Seed bed preparation	0.0	0.0
Compost/Animal penning	1,553 (26)	1,392 (24)
Planting	589 (10)	570 (10)
Seed cost	1,050 (18)	1,023 (17)
Seed treatment	0.0	0.0
Fertilizer cost	1,951 (33)	1,767 (30)
Micro-nutrient/Chemicals	2,135 (36)	2,013 (34)
Interculture	0.0	0.0
Weeding	1,656 (28)	1,581 (27)
Plant protection	0.0	0.0
Irrigation	90 (2)	76 (1)
Watching	0.0	0.0
Harvesting	1,349 (23)	1,294 22)
Threshing	2,447 (41)	2,127 (36)
Marketing	186 (3)	157 (3)
Total-Variable cost (TVC)/ha	15,401 (261)	14,155 (240)
Fixed cost/ha	9,877 (167)	9,005 (153)
Total cost (TC)/ha	25,278 (428)	23,160 (393)
Grain yield (qtl/ha)	21.76	14.78
Price ₹ ($)/qtl	1,310 (22)	1,315 (22)
By-product (qtl/ha)	32.55	24.22
Price ₹ ($)/qtl	210 (3)	184 (3)
Gross Returns ₹ ($)/ha	35,345 (599)	23,892 (405)
COP (VC) for grain ₹ ($)/qtl	708 (12)	958 (16)
Net Returns ₹ ($)/ha	10,067 (171)	732 (12)
Benefit-cost ratio	1.40	1.03

Note: Figures in parenthesis indicates US$

Table 6.22. Relative performance of hybrids with and without HPRC parents in Gujarat in ₹ (US$)/ha, 2013-14.

Activity	Hybrids with HPRC parents	Hybrids without HPRC parents
Land preparation	2,396 (41)	2,391 (41)
Seed bed preparation	0.0	0.0
Compost/Animal penning	1,553 (26)	1,392 (24)
Planting	589 (10)	869 (15)
Seed cost	1,050 (18)	1,223 (21)
Seed treatment	0.0	0.0
Fertilizer cost	1,951 (33)	1,864 (32)
Micro-nutrient/Chemicals	2,135 (36)	2,249 (38)
Interculture	0.0	0.0
Weeding	1,656 (28)	1,758 (30)
Plant protection	0.0	0.0
Irrigation	90 (2)	130 (2)
Watching	0.0	0.0
Harvesting	1,349 (23)	2,179 (37)
Threshing	2,447 (41)	2,715 (46)
Marketing	186 (3)	157 (3)
Total-Variable cost (TVC)/ha	15,401 (261)	16,927 (287)
Fixed cost/ha	9,877 (167)	9,588 (163)
Total cost (TC)/ha	25,278 (428)	26,515 (449)
Grain yield (qtl/ha)	21.76	18.57
Price ₹ ($)/qtl	1,310 (22)	1,310 (22)
By-product (qtl/ha)	32.55	30.22
Price ₹ ($)/qtl	210 (3)	199 (3)
Gross Returns ₹ ($)/ha	35,345 (599)	30,392 (515)
COP (VC) for grain ₹ ($)/qtl	708 (12)	912 (15)
Net Returns ₹ ($)/ha	10,067 (171)	3,877 (66)
Benefit-cost ratio	1.40	1.15

Figures in the parenthesis indicates US$

6.12.3 Profitability of HPRC hybrids over the hybrids replaced by them in Rajasthan, 2013-14

The relative profitability of the HPRC hybrids *vis-à-vis* the hybrids replaced by them is illustrated in Table 6.23. The cost of cultivation of the HPRC hybrids was higher than that of the hybrids replaced by them by US$68 per ha. But the gross returns were also higher by US$241 per ha, because of higher grain and fodder yields achieved by the HPRC hybrids. The net returns from HPRC hybrids exceeded those from the hybrids replaced by them by US$173 per ha. The benefit-cost ratio was far higher at 1.32 when compared with that for the hybrids replaced by them. The hybrids replaced by the HPRC hybrids were just able to break even, with only a marginal surplus. The cost of production per quintal of grain was only US$16 in case of the HPRC hybrids, while it was much higher at US$19 per quintal of grain in case of the hybrids replaced by the HPRC hybrids. Both the private as well as the social benefits were much higher in case of the HPRC hybrids when compared with those replaced by them.

Table 6.23. Relative performance of HPRC hybrids and the hybrids replaced by them in Rajasthan in ₹ (US$)/ha, 2013-14.

Activity	Hybrids with HPRC parents	Hybrids replaced by HPRC hybrids
Land preparation	2,313 (39)	2,017 (34)
Seed bed preparation	9 (0)	15 (0)
Compost/Animal penning	3,070 (52)	2,670 (45)
Planting	1,971 (33)	1,656 (28)
Seed cost	1,135 (19)	871 (15)
Seed treatment	419 (7)	0 (0)
Fertilizer cost	2,496 (42)	1,945 (33)
Micro-nutrient/Chemicals	39 (1)	31 (1)
Interculture	1,833 (31)	1,532 (26)
Weeding	1,656 (29)	1,622 (27)
Plant protection	15 (0)	0 (0)
Irrigation	2,294 (39)	2,029 (34)
Watching	238 (4)	129 (2)
Harvesting	4,839 (82)	4,473 (76)
Threshing	2,514 (43)	2,087 (35)
Marketing	290 (5)	185 (3)
Total-Variable cost (TVC)	25,177 (427)	21,262 (360)
Fixed cost/ha	8,814 (149)	8,713 (148)
Total cost (TC)	33,991 (576)	29,975 (508)
Grain yield (qtl/ha)	27.28	19. 15
Price ₹ (US$)/qtl	1,137 (19)	1,116 (19)
By-product (qtl/ha)	38.70	27.10
Price ₹ (US$)/qtl	360 (6)	345 (6)
Gross Returns ₹ (US$)/ha	44,943 (762)	30,721 (521)
CO(VC) for grain ₹ (US$)/qtl	923 (16)	1,110 (19)
Net Returns ₹ (US$)/ha	10,952 (186)	746 (13)
Benefit-cost ratio	1.32	1.02

Figures in the parenthesis indicates US$

6.12.4 Profitability of HPRC hybrids *vis-à-vis* non-HPRC hybrids in Rajasthan sample, 2013-14

Compared to Gujarat, the cost of production of pearl millet was much higher in Rajasthan both for HPRC hybrids and non-HPRC hybrids. The total cost of production of HPRC hybrids added up to US$576 per ha (Table 6.24), but the gross returns were also higher at US$762 per ha on account of higher yields and better fodder prices. The net profit worked out to US$186 per ha, yielding a benefit-cost ratio of 1.32. However, the unit cost of production was much higher at US$16 per quintal. The cost of cultivation of non-HPRC hybrids was slightly lower at US$558 per ha. However, the gross returns were much lower at US$612 per ha due to lower yields of grain and fodder. The net profit was only US$55 per ha and the benefit-cost ratio was only 1.10. Thus, the better performance of HPRC hybrids is reflected in higher grain and fodder yields and lower unit cost of production. Farmers received about 32% returns on the investment in case of the HPRC hybrids, while the return on investment was only 10% in case of the non-HPRC hybrids. These findings were in confirmity with Gajja et al. (2014) in arid Rajasthan.

Table 6.24. Relative performance of hybrids with and without HPRC parents in Rajasthan in ₹ (US$)/ha, 2013-14.

Activity	Hybrids with HPRC parents	Hybrids without HPRC parents
Land preparation	2,313 (39)	2,160 (37)
Seed bed preparation	9 (0)	73 (1)
Compost/Animal penning	3,070 (52)	2,539 (43)
Planting	1,971 (33)	1,951 (33)
Seed cost	1,135 (19)	1,461 (25)
Seed treatment	419 (7)	0 (0)
Fertilizer cost	2,496 (42)	2,382 (40)
Micro-nutrient/Chemicals	39 (1)	18 (0)
Interculture	1,833 (31)	1,732 (29)
Weeding	1,702 (29)	1,701 (29)
Plant protection	15 (1)	0 (0)
Irrigation	2,294 (39)	2,088 (35)
Watching	238 (4)	62 (1)
Harvesting	4,839 (82)	4,768 (81)
Threshing	2,514 (43)	2,435 (41)
Marketing	290 (5)	209 (4)
Total-Variable cost (TVC)	25,177 (427)	23,579 (400)
Fixed cost/ha	8,814 (149)	9,313 (158)
Total cost (TC)	33,991 (576)	32,892 (558)
Grain yield (qtl/ha)	27.28	22.03
Price ₹ (US$)/qtl	1,137 (19)	1,116 (19)
By-product (qtl/ha)	38.70	31.00
Price ₹ (US$)/qtl	360 (6)	372 (6)
Gross Returns ₹ (US$)/ha	44,943 (762)	36,114 (612)
COP (VC) for grain ₹ (US$)/qtl	923 (16)	1,070 (18)
Net Returns ₹ (US$)/ha	10,952 (186)	3,222 (55)
Benefit-cost ratio	1.32	1.10

Figures in the parenthesis indicates US$

The unit cost of production per quintal dropped by 11% from US$18 per quintal to US$16 per quintal on account of the availability of HPRC hybrids. The unit cost reduction of US$2 per quintal is the social benefit and it benefits both the producers and consumers immensely.

6.12.5 Profitability of HPRC hybrids *vis-à-vis* hybrids replaced by them in Uttar Pradesh, 2013-14

The primary reason for the adoption of HPRC hybrids in the place of earlier hybrids (earlier generation hybrids, older HPRC hybrids and non-HPRC hybrids) is their superior performance in terms of higher yields and better return on the investment. Farmers who adopted HPRC hybrids spend more on inputs and labor when compared to those invested on the replaced hybrids. Because of higher grain and fodder yields, the harvesting, threshing and marketing costs are also higher. Thus, the cost of cultivation per ha was as high as US$649 per ha (Table 6.25). It was higher by US$70 than that in case of the replaced hybrids. Yet, the grain yield was higher by 38% and the fodder yield was higher by 34% than those achieved by the

Table 6.25. Relative performance of hybrids with and without HPRC parents in Uttar Pradesh in ₹ (US$)/ha, 2013-14.

Activity	Hybrids with HPRC parents	Hybrids replaced by HPRC Hybrids
Land preparation	3,384 (57)	2,718 (47)
Seed bed preparation	18 (0)	10 (0)
Compost/Animal penning	4,243 (72)	3,892 (66)
Planting	1,932 (33)	1,896 (32)
Seed cost	1,699 (29)	1,504 (26)
Seed treatment	63 (1)	46 (1)
Fertilizer cost	1,214 (21)	1,056 (18)
Micro-nutrient/Chemicals	23 (0)	15 (0)
Interculture	4,371 (74)	3,954 (67)
Weeding	219 (4)	205 (3)
Plant protection	63 (1)	58 (1)
Irrigation	1,034 (18)	962 (16)
Watching	5 (0)	8 (0)
Harvesting	6,417 (109)	5,868 (99)
Threshing	3,364 (57)	3,105 (53)
Marketing	762 (13)	604 (10)
Total-Variable cost (TVC)	28,811 (488)	25,901 (439)
Fixed cost/ha	9,482 (161)	8,250 (140)
Total cost (TC)	38,293 (649)	34,151 (579)
Grain yield (qtl/ha)	39.35	28.55
Price ₹ (US$)/qtl	1,128 (19)	1,107 (19)
By-product (qtl/ha)	55.40	41.26
Price ₹ (US$)/qtl	162 (3)	150 (3)
Gross Returns ₹ (US$)/ha	53,362 (905)	37,794 (641)
COP (VC) for grain ₹ (US$)/qtl	732 (12)	907 (15)
Net Returns ₹ (US$)/ha	15,069 (256)	3,643 (62)
Benefit-cost ratio	1.39	1.11

Figures in the parenthesis indicates US$

replaced hybrids. The gross returns from the HPRC hybrids added up to US$905 per ha in comparison to US$641 obtained in case of the replaced hybrids. The net returns were as high as US$256 per ha, which were about five times the net returns (US$62) per ha from the replaced hybrids. The benefit-cost ratio was 1.39 in case of HPRC hybrids as against 1.11 recorded by the replaced hybrids. Due to higher productivity, the cost of production of pearl millet per quintal was only US$12.4 in case of the HPRC hybrids, despite the higher cost of cultivation incurred on them. In contrast, the cost of production per quintal was much higher at US$15.4 in case of the replaced hybrids. Obviously, shifting to HPRC hybrids gave an additional private benefit of US$194 per ha. It also gave an additional social benefit of US$3 per quintal by way of reduced cost of production.

6.12.6 Profitability of HPRC hybrids *vis-à-vis* the non-HPRC hybrids in Uttar Pradesh, 2013-14

The cost of cultivation of HPRC hybrids in Uttar Pradesh was even higher than those in Gujarat and Rajasthan. The total cost of cultivation was computed as US$649 per ha. But both the grain and fodder yields of HPRC hybrids were much higher in Uttar Pradesh than in the other two states. As a result, the

gross returns were higher at US$905 per ha (Table 6.26). The net profit per ha was also the highest at US$256, yielding a benefit-cost ratio of 1.39. Relative to HPRC hybrids, non-HPRC hybrids reported a much lower total cost of cultivation. But, owing to lower grain and fodder yields, the gross returns were lower at US$745 per ha. The net profit per ha was only US$133, yielding a benefit-cost ratio of only 1.22. The unit variable cost of production per quintal of grain was US$14.37 in case of non-HPRC hybrids as compared to US$12.41 for HPRC hybrids. Thus, there was a unit cost reduction of 13.70% due to the HPRC hybrids. The saving in cost of production by US$1.97 is the benefit accruing to society on account of the development and use of HPRC hybrids by the pearl millet farmers of Uttar Pradesh sample when compared with the non-HPRC hybrids.

6.13 Quantification of social benefits on account of HPRC hybrids, 2013-14

In this section, we attempted to estimate the total benefits attributable to the development and use of the HPRC hybrids per year in the three states. In Gujarat, 90% pearl millet area is estimated to be under

Table 6.26. Relative performance of hybrids with and without HPRC parents in Uttar Pradesh in ₹ (US$)/ha, 2013-14.

Activity	Hybrids with HPRC parents	Hybrids without HPRC parents
Land preparation	3,384 (57)	2,979 (50)
Seed bed preparation	18 (0)	31 (1)
Compost/Animal penning	4,243 (72)	2,925 (50)
Planting	1,932 (33)	1,646 (28)
Seed cost	1,699 (29)	1,742 (30)
Seed treatment	63 (1)	0
Fertilizer cost	1,214 (21)	3,185 (54)
Micro-nutrient/Chemicals	23 (0)	0
Interculture	4,371 (74)	4,654 (79)
Weeding	219 (4)	0
Plant protection	63 (1)	0
Irrigation	1,034 (18)	1,024 (17)
Watching	5 (0)	0
Harvesting	6,417 (109)	5,334 (90)
Threshing	3,364 (57)	2,995 (51)
Marketing	762 (13)	1,302 (22)
Total-Variable cost (TVC)	28,811 (488)	27,817 (471)
Fixed cost/ha	9,482 (161)	8,308 (141)
Total cost (TC)	38,294 (649)	36,124 (612)
Grain yield (qtl/ha)	39.35	32.78
Price ₹ (US$)/qtl	1,128 (19)	1,172 (20)
By-product (qtl/ha)	55.40	42.70
Price ₹ (US$)/qtl	162 (3)	130 (2)
Gross Returns ₹ (US$)/ha	53,362 (905)	43,969 (745)
COP (VC) for grain ₹ (US$)/qtl	732 (12)	848 (14)
Net Returns ₹ (US$)/ha	15,085 (256)	7,848 (133)
Benefit cost ratio	1.39	1.22

Figures in the parenthesis indicates US$

hybrids (Our sample estimates are higher than 95% but the expert opinion estimate it at 90% in the whole state) and 75% of the hybrid area was estimated to be under HPRC hybrids (sample survey estimate). We estimate that about 527,000 ha area is under HPRC hybrids and the benefits attributable to HPRC hybrids in Gujarat are estimated at US$39.5 million (Table 6.27). In Rajasthan, it was assumed that only 35% of the pearl millet area is under hybrids (Our sample estimates are as high as 90% but the expert opinion puts it at 35% at the state level due to the dominance of landraces in western Rajasthan) and that only 48% of the hybrid area is under HPRC hybrids (based on the sample survey estimate). Thus, it is estimated that about 812,000 ha are under HPRC hybrids. The benefits attributable to the development and use of HPRC hybrids were estimated at US$55.2 million). In Uttar Pradesh, about 90% area is believed to be under hybrids (although the sample estimates are higher than 95%, the expert opinion puts it at 90% at the state level) and 62% of the hybrid area is under HPRC hybrids (based on the sample survey estimate). The area under HPRC hybrids in Uttar Pradesh is estimated at 506,000 ha. The social benefits by way of cost reduction are estimated at US$39.0 million in Uttar Pradesh. The total benefits attributable to the HPRC hybrids in the three states of Gujarat, Rajasthan and Uttar Pradesh are estimated at US$133.7 million). If the area under HPRC hybrids in other states like Maharashtra, Haryana, Madhya Pradesh, Karnataka, etc., is also considered, the total benefits on account of HPRC hybrids could perhaps reach US$150 million–US$200 million per year. Of course, these social benefits are shared by the farmers who adopted the HPRC hybrids, consumers, seed companies, traders and other stakeholders.

Table 6.27. Estimation of social benefits due to HPRC hybrids in Rupees million (US$million), 2013-14.

S.No	Item	Gujarat	Rajasthan	Uttar Pradesh	Total/Average
1	Unit cost reduction ₹ (US$) qtl	204 (3.46)	147 (2.49)	116 (1.97)	156 (2.64)
2	Average grain yield (qtl/ha)	21.76	27.28	39.35	29.46
3	Additional benefit ₹ (US$) per hectare	4,439 (75)	4,010 (68)	4,565 (77)	4,338 (74)
4	Total area ('000 ha) per year- Average of 2011-13	780	4,833	908	6,473
5	Hybrid area (%)*	90	35	90	72
6	Hybrid area ('000 ha)/year	702	1692	817	3,211
7	% of HPRC hybrid area	75	48	62	57
8	HPRC hybrid area ('000 ha)/year	527	812	506	1,845
9	Total benefits [₹ million (US$ million)/year]	2,339 (39.5)	3,256 (55.2)	2,310 (39.0)	7,905 (133.7)

* Estimates based on seed sales data
Note: Figures in the parenthesis indicates US$

A recent study conducted by D Kumara Charyulu et al. (2017, accessed at http://oar.icrisat.org/9993/) of ICRISAT economics program in Maharashtra estimated that the benefits attributable to the hybrids released after 2005 have brought a total benefit of US$103.3 million. The comparison was between the hybrids released/marketed prior to 2005 and those that were released/marketed after 2005. They concluded that the post-2005 hybrids represented a technical change and that it resulted in a unit cost reduction of US$2.61 per quintal of pearl millet. In our case, the comparison is between HPRC hybrids and non-HPRC hybrids. We estimated that the HPRC hybrids resulted in a cost reduction of US$2.64 per quintal over the non-HPRC hybrids during 2013-14.

Overall, our estimate of a total benefit of US$150-200 million per year attributable to HPRC hybrids in the country is quite conservative and forms the lower bound for the benefits attributable to HPRC hybrids in the country.

6.13.1 Estimation of social benefits during 2011-12, 2012-13 and 2013-14

The cost of cultivation data were collected only for the cropping year, 2013-14. However, the yields were collected from the farmers for three years, 2011-12, 2012-13 and 2013-14. The unit cost reduction caused by HPRC hybrids was estimated for the data collected under the cost of cultivation module for the year, 2013-14. Since we have the estimates of areas under HPRC and non-HPRC hybrids for three years, an attempt was made to estimate the social benefits on account of the HPRC hybrids for the three years, 2011-12, 2012-13 and 2013-14. These estimates suggest that the total benefits from HPRC hybrids during the three years were US$401.1 million from the three study states, Gujarat, Rajasthan and Uttar Pradesh (Table 6.28). These high returns estimated justify the investments made on HPRC at ICRISAT and those made by the seed companies for evolving them. However, since we have no data on the costs, we are unable to generate any estimates of benefit-cost ratios. The returns on research investments were not also estimated due to non-availability of proper cost data.

Table 6.28. Estimation of the benefits by individual years.

Year	Item	Gujarat	Rajasthan	Uttar Pradesh	Total/Average
2011-12	Average reduction in social cost [₹ (US$) ha]	4,439 (75.24)	4,010 (67.97)	4,565 (77.37)	4,338 (73.53)
	Area under HPRC hybrids ('000 ha)	498	807	465	1,798
	Total social benefits [₹ million (US$ million)]	2,210.6 (36.8)	3,236 (53.9)	2,122 (35.4)	7,799 (129.9)
2012-13	Average reduction in social cost [₹ (US$) ha]	4,439 (75.24)	4,010 (67.97)	4,565 (77.37)	4,338 (73.53)
	Area under HPRC hybrids ('000 ha)	533.5	773	470	1,798
	Total social benefits [₹ million (US$ million)]	2,368 (39.47)	3,099 (51.66)	2,145 (35.75)	7,799 (129.9)
2013-14	Average reduction in social cost [₹ (US$) ha]	4,439 (75.24)	4,010 (67.97)	4,565 (77.37)	4,438 (73.53)
	Area under HPRC hybrids ('000 ha)	540	827	547	1910
	Total social benefits [₹ million (US$ million)]	2,397 (39.9)	3,316 (55.27)	2,497 (41.6)	8,476 (141.3)

6.14 Competitiveness of pearl millet in the study states

Pearl millet is an important crop during the rainy season in North Gujarat. Sampled farmers were able to recover all the costs and earn a net profit of US$118.47 per ha (Table 6.29). It gave a benefit-cost ratio of 1.27. Cluster bean is another important crop competing with pearl millet for area. Relative to conservative expenditure on pearl millet, the variable costs were much higher at US$458.59 per ha. The total cost of production swelled up to US$605.12 per ha due to considerable rental value of land. But the gross returns were only US$636.34 per ha, leaving a surplus of US$31.22. The benefit-cost ratio worked out to only 1.05. So, it proved to be a less profitable crop than pearl millet. Thus, pearl millet occupied the middle position, proving to be more profitable than another field crop, cluster bean but far less profitable than a commercial vegetable crop, bottle gourd.

Table 6.29. Costs and returns of rainy season crops in Gujarat (₹ per ha).

Activity	Pearl millet	Cluster bean
Land preparation	2394	2371
Seed bed preparation	0	0
Compost/Animal penning	1,473	9,238
Planting	729	1,753
Seed cost	1,137	2,361
Seed treatment	0	0
Fertilizer cost	1,907	3,058
Micro-nutrient/Chemicals	2,192	0
Interculture	0	0
Weeding	1,707	1,532
Plant protection	0	0
Irrigation	110	0
Watching	0	0
Harvesting	1,765	2,594
Threshing	2,581	3,927
Marketing	171	222
Total-Variable cost (₹/ha)	16,166	27,057
Fixed cost ₹/ha	9,732	8,645
Total cost (TC) ₹/ha	25,898	35,702
Grain yield (qtl/ha)	20.17	NA
Price (₹/qtl)	1,332	NA
By-product (qtl/ha)	32.80	NA
Price (₹/qtl)	184	NA
Gross returns ₹/ha	32,888	37,544
Net returns over TC (₹/ha)	6,990	1,842
Net returns over VC (₹/ha)	16,721	10,487
Net returns over VC (US$/ha)	283	178
BCR	1.27	1.05

Note: US$ = Rupees 59

The cost of cultivation of pearl millet was much higher in Rajasthan than in Gujarat. The total cost of cultivation was as high as US$560.01 per ha (Table 6.30); the gross returns were also much higher due to higher yields of grain and fodder and higher price of fodder. Pearl millet gave a net profit of US$129.73 per ha and a benefit-cost ratio of 1.23. The cost of cultivation of cotton was higher than that of pearl millet by 40%. Yet, it gave very high returns due to high yield as well as attractive price to record a gross return of US$2175.35. It yielded a net return of US$1388.97 and a benefit-cost ratio of 2.77. Such bumper returns do not come every year but it did happen in 2013-14. However, cluster bean, which is usually a profitable crop, hardly broke even due to low output price. Its cost of cultivation was even higher than that of cotton, but the gross returns just covered the total cost of cultivation and left a small surplus of US$70.10. The benefit-cost ratio was only 1.09. Groundnut was another important field crop in the study area. Its cost of cultivation was the highest of all the crops due to high expenditure on organic manures, seed and labor. The total cost of cultivation was as high as US$959.10 per ha, but the care bestowed by the farmers on the crop paid rich dividends by way of good yield and attractive price. They could earn a gross return of

Table 6.30. Costs and returns of rainy season crops in Rajasthan (₹ per ha).

Activity	Pearl millet	Cotton	Cluster bean	Groundnut
Land preparation	3,237	3,691	3,832	4,033
Seed bed preparation	41	0	0	19
Compost/Animal penning	2,804	1,709	6,273	8,153
Planting	1,961	2,345	1,952	2,609
Seed cost	1,298	4,618	4,142	11,609
Seed treatment	210	1,622	47	90
Fertilizer cost	3,091	4,390	3,244	1,577
Micro-nutrient	29	0	53	190
Interculture	1,683	1,064	5,429	4,315
Weeding	1,702	1,273	979	2,295
Plant protection	8	3,319	37	38
Irrigation	291	2,691	1,697	2,409
Watching	150	0	414	205
Harvesting	4,803	5,545	7,082	5,229
Threshing	2,424	6,337	4,867	5,967
Marketing	250	763	361	401
Total-Variable cost (₹/ha)	23,982	39,368	40,409	49,139
Fixed cost (₹/ha)	9,058	7,029	6,995	7,448
Total cost (₹/ha)	33,041	46,396	47,404	56,587
Grain yield (qtl /ha)	24.65	40.18	NA	NA
Price (₹/qtl)	1,126	3,194	NA	NA
By-product (qtl/ha)	35.35	-	NA	NA
Price (₹/ton)	366	-	NA	NA
Gross returns (₹/ha)	40,694	1,28,346	51,539	77,016
Net returns over TC (₹/ha)	7,654	81,949	4,136	20,429
Net returns over VC (₹/ha)	16,712	88,978	11,131	27,878
Net returns over VC (US$/ha)	283	1,508	189	473
BCR	1.23	2.77	1.09	1.36

Note: US$ = Rupees 59

US$1305.36, giving a net profit of US$346.26. It yielded a benefit-cost ratio of 1.36. Thus, pearl millet gave medium profit, higher than cluster bean, but lower than groundnut. As was expected, the commercial crop, cotton, was the most profitable during the rainy season of 2013-14 for the sampled farmers in Rajasthan.

In case of Uttar Pradesh sample, pearl millet yielded a benefit-cost ratio of 1.31 (Table 6.31). It was higher than that of maize but was much lower than that for cluster bean and sorghum fodder. The cost of cultivation of pearl millet was much higher in Uttar Pradesh sample than those in Gujarat and Rajasthan. But it gave much higher returns than in the other two states due to higher levels of grain and fodder yields. The net returns per ha from pearl millet were the highest in Uttar Pradesh at US$349, when compared to US$283 reported in case of the other two states; so was the benefit-cost ratio estimated at 1.31. The cluster bean crop, which was less profitable than pearl millet in Gujarat and Rajasthan, turned out to be the most profitable one in the Uttar Pradesh sample. Sorghum fodder also yielded better benefit-cost ratio than pearl millet in Uttar Pradesh.

Table 6.31. Costs and returns of rainy season crops in Uttar Pradesh (₹ per ha).

Activity	Pearl millet	Cluster bean	Sorghum fodder	Maize
Land preparation	3,168	2,825	1,982	1,731
Seed bed preparation	26	0	0	0
Compost/Animal penning	3,634	8,940	695	241
Planting	1,735	1,425	2,043	1,523
Seed cost	1,687	1,126	1,827	1,003
Seed treatment	0	0	0	0
Fertilizer cost	2,118	1,348	997	1,139
Micro-nutrient	12	0	0	0
Interculture	4,484	4,331	562	4,890
Weeding	171	0	0	0
Plant protection	0	249	0	0
Irrigation	1,027	2,651	314	818
Watching	2	0	0	375
Harvesting	5,920	4,897	7,571	14,193
Threshing	3,233	571	542	5,882
Marketing	879	624	0	375
Total-Variable cost (₹/ha)	28,097	28,986	16,533	32,171
Fixed cost (₹/ha)	8,956	17,282	7,507	6,455
Total cost (₹/ha)	37,053	46,268	24,040	38,626
Grain yield (qtl/ha)	36.35	40.00	2.72	35.68
Price (₹/qtl)	1,146	3,866	1,600	1,266
By-product (qtl/ha)	49.78	0.00	283.50	13.5
Price (₹/qtl)	142	0	137	82
Gross returns ₹/ha	48,698	1,54,639	43,325	46,283
Net returns over TC ₹/ha	11,645	1,08,371	19,285	7,657
Net returns over VC ₹/ha	20,601	1,25,653	26,792	14,112
Net returns over VC $/ha	349	2,130	454	239
BCR	1.31	3.34	1.80	1.20

Note: 1 US$= Rupees 59

Thus, pearl millet could recover both the variable and fixed costs of cultivation in all the three states and gave benefit-cost ratios higher than one. Nevertheless, it was less profitable than other competing crops during rainy season.

6.15 Average asset values of the sample households

The average asset values of the sample households in the three states are presented in Table 6.32. The asset values were the highest in the Uttar Pradesh sample and the lowest in Gujarat, with Rajasthan falling in the middle. The major difference was with respect to the land values only. Although the landholdings were larger in Gujarat than in the other two states, the land prices were higher in the other two states. The location factors as well profit earning opportunities were favorable in Uttar Pradesh and Rajasthan when compared to Gujarat. Hence, the land values per household were only US$75,000 in Gujarat, compared to US$95,750 in Rajasthan and US$102,470 in Uttar Pradesh. Besides land values, the value of farm buildings was also highest in Uttar Pradesh. Rajasthan leads other states in the values of livestock and

Table 6.32. Average values of household assets across regions (₹ '000 per household).

Item	Gujarat (N=147)	Rajasthan (N=272)	Uttar Pradesh (N=144)
Total land value	4,408	5,649	6,046
1.Irrigated	4,321	3,954	4,027
2. Dryland	24	1,278	1,717
3. Fallow land	63	417	301
Total livestock value	154	197	92
Draft	12	12	3
Buffaloes	122	158	78
Others	20	27	11
Total farm equipment	202	163	156
Total farm buildings	199	212	366
Total consumer durables	177	201	124
Total assets value (₹ '000 per hh)	**5,140**	**6,422**	**6,784**
Total assets value ($ '000 per hh)	**87.12**	**108.85**	**114.99**

consumer durables. Gujarat leads others in the value of farm equipment. The total asset value was the highest at US$115,000 in Uttar Pradesh, followed by US$109,000 in Rajasthan and US$87,000 in Gujarat.

6.16 Average household incomes in the study states

The average household incomes earned by the sampled farmers in the three study states are summarized in Table 6.33. Just as in case of asset values, Uttar Pradesh farmers recorded higher incomes than their counterparts in the other two states. Income from crops and orchards contributed more than 50% of the total household income in Gujarat and Uttar Pradesh, while its contribution was only 30% in case of the Rajasthan. In Gujarat, livestock rearing contributed 30% of the income. Salaried income, business income and non-farm labor income provided significant additions to income. Other sources like farm labor, caste occupation, rental income, outmigration and other sources added trickles to the income stream. In Rajasthan, livestock rearing/hiring out bullocks contributed almost the same share as farming. Salaried

Table 6.33. Annual average household income across states (₹ '000 per household).

Source of Income	Gujarat (N=147)	Rajasthan (N=272)	Uttar Pradesh (N=144)
Agriculture	50.50	27.97	107.56
Farm Labor	0.94	1.77	12.04
Non-Farm Labor	2.18	3.89	9.74
Livestock and hiring of bullocks	32.75	27.55	21.00
Caste Occupation	0.65	0.00	0.00
Business	3.89	3.54	10.21
Govt. Development Programs	0.00	0.65	0.00
Salaried	5.72	20.06	18.29
Rental income on farm equipment	1.00	1.12	12.69
Out migration	0.30	5.13	5.37
Others	1.83	0.59	4.78
Grand Total (₹ '000 per hh)	**99.77**	**92.28**	**201.66**
Grand Total (US$ '000 per hh)	**1.691**	**1.564**	**3.418**

income added 20% of the income. Outmigration, non-farm labor and business made useful contributions. Farm labor, rental income, government development programs and other sources added small amounts. In the Uttar Pradesh sample, income sources were more diversified. Livestock rearing, rental income, farm labor, business income and non-farm labor provided substantial supplement to agricultural income. Outmigration and other sources contributed marginally to the income.

6.17 Annual average household expenditures in the study states

While there was considerable variation in household incomes of the three states, the household expenditure did not show much variation between the three states. An average household in the Uttar Pradesh sample spent about 50% of their household income on consumption (Table 6.34). In the case of the Gujarat sample, an average household spent 75% of its income for consumption. However, in case of Rajasthan, a household had to spend 96% of its income on consumption. Gujarat households spent 23% of consumption expenditure on food grains (cereals and pulses) and 36% on other food articles, raising the food expenditure to 59% of the consumption expenditure. 7.3% was spent on education and 5.9% on health. About 8.8% was spent on clothing, ceremonies and travel and entertainment. The remaining 19% was spent on other non-food expenditures like electricity charges, telephone, cosmetics, taxes, etc. In the Rajasthan sample, 24% of the consumption expenditure was on food grains. Another 34% was spent on other food articles, raising the expenditure on food to 58% of the consumption expenditure. Expenditure on education was higher at 17%, but the expenditure on health was relatively lower at 6.2%. The expenditures on clothing, ceremonies, entertainment and travel added up to 10.3%. Other non-food expenditure was limited to 8.9%. The expenditure on food grains constituted only 17.1% of the consumption expenditure in the Uttar Pradesh sample. But, the expenditure on other food articles was quite high at 45.5%, taking the total food expenditure to 62.6%. 9.1% was spent on education and 4.6% on

Table 6.34. Average household consumption across the study states (₹ '000 per household).

Item	Gujarat (N=147)	Rajasthan (N=272)	Uttar Pradesh (N=144)
Rice	1.18	0.65	0.83
Wheat	4.60	14.51	10.33
Pearl millet	7.20	3.30	3.72
Other cereals	1.30	0.00	0.06
Pigeonpea	0.47	0.00	0.89
Chickpea	0.53	2.71	0.06
Other pulses	1.59	0.18	1.18
Milk	6.49	8.61	15.34
Other milk products	2.77	4.01	5.13
Cooking oils	5.25	2.48	2.01
Non-vegetarian	0.71	1.06	0.47
Other food expenditure	11.51	13.63	22.48
Health	4.37	5.49	4.60
Clothing	3.54	6.02	6.43
Education	5.43	14.99	9.09
Ceremonies	1.12	0.94	6.25
Entertainment/travel	1.89	2.18	4.13
Others	14.40	7.85	6.90
Grand Total (₹ '000 per hh)	**74.34**	**88.50**	**99.89**
Grand Total (US$ '000 per hh)	**1.26**	**1.50**	**1.69**

health. The expenditure on clothing, ceremonies, entertainment and travel constituted 16.8% of the total consumption expenditure. The remaining 6.9% was spent on other non-food items.

Gujarat sample alone spent major part of its food grain expenditure on pearl millet, the main staple food. 9.7% of the total consumption expenditure was incurred on pearl millet. However, in Rajasthan and Uttar Pradesh samples, the primary grain of consumption was wheat. They also consumed pearl millet, but the expenditure on it constituted a mere 3.7% of the consumption expenditure in both these samples.

6.18 Utilization of pearl millet by the sample households

The pattern of utilization of pearl millet in the three states is summarized in Table 6.35. In Gujarat, 39.7% of the production was consumed as food. 33.9% was sold in the market and 19.2% of the production was used as animal feed. About 5.5% was given out as gift or for kind payment. The remaining 3.1% was kept in store. They used 55.2% of the fodder produced to feed their animals. 18.6% sold in the market, while 26.7% was kept in store. In Rajasthan, the sampled farmers consumed only 18.4% of the grain produced for consumption and sold 72.2% of the production in the market. Only small quantities were used for gifts and kind payments, feed, seed and for holding stock. They, however, used 90% of the fodder produced for feeding their animals. Only 9.4% of it was sold in the market and the remaining quantity was used for keeping stock and making kind payments. In the Uttar Pradesh sample, 17.9% of the grain produced was used for food. 58.6% of the production was sold in the market. They used 13.9% of the grain for feeding livestock. 7.4% of the production was kept in stock. The remaining quantity was used for making kind payments. 54% of the fodder produced was fed to their animals and 32% was sold in the market. A small quantity was given as gift and the remaining fodder was kept in store.

In Gujarat, farmers incurred US$1.47 per quintal of grain and US$0.27 per quintal of fodder towards marketing (Table 6.36). In Rajasthan, the marketing costs were lower at US$1.07 per quintal of grain and

Table 6.35. Pearl millet output utilization in 2013-14 (Qtl/household).

	Gujarat (N=147)		Rajasthan (N=272)		Uttar Pradesh (N=144)	
Item	Grain	Fodder	Grain	Fodder	Grain	Fodder
Total Production	17.36	31.15	23.74	31.81	29.37	36.75
Saved as seed	0.00	0.00	0.04	0.00	0.03	0.00
Gift/kind payments	0.96	0.06	0.53	0.03	0.75	0.53
Used as food	6.89	0.00	4.36	0.00	5.27	0.00
Used as feed	3.33	17.19	0.74	28.61	4.08	19.85
Sold in market	5.88	5.78	17.13	3.00	17.21	11.74
In store	0.54	8.32	0.58	0.17	2.03	4.63

Table 6.36. Pearl millet marketing costs in 2013-14 (₹/qtl).

	Gujarat (N=147)		Rajasthan (N=272)		Uttar Pradesh (N=144)	
Type of cost	Grain	Fodder	Grain	Fodder	Grain	Fodder
Bagging cost	10.62	0.00	18.88	0.59	NA	NA
Transportation cost	24.19	4.72	30.09	1.77	NA	NA
Commission agent cost	15.34	2.36	2.95	1.18	NA	NA
Market fee	8.26	3.54	5.31	0.00	NA	NA
Labor cost	28.32	5.31	5.90	7.08	NA	NA
Marketing cost ₹/qtl	86.73	15.93	63.13	10.62	75.52	5.90
Marketing cost US$/qtl	1.47	0.27	1.07	0.18	1.28	0.10
Avg Qty sold/hh (qtl)	5.88	5.78	17.13	3.00	17.21	11.74

US$0.18 per quintal of fodder. The marketing costs incurred by farmers in Uttar Pradesh were medium at US$1.28 per quintal of grain and US$0.10 per quintal of fodder. The marketed quantities were the highest in Uttar Pradesh. Rajasthan sample farmers sold more grain and less fodder in the market, while Gujarat farmers sold them in equal measure.

6.19 Perceptions about benefits from pearl millet technology

The sampled farmers in all the three study states felt that they were immensely benefited by pearl millet production technology over the last decade (see Table 6.37). Uttar Pradesh farmers felt that their pearl millet grain yields increased by 94%. Gujarat sample farmers opined that their yield increased by 42%, while Rajasthan farmers indicated that their yields increased by about 30%. Similarly, Uttar Pradesh farmers endorsed that their fodder yields increased by 45%. Gujarat farmers perceived that their fodder yields increased by 37%, while Rajasthan farmers perceived that their fodder yields increased by 26%. Gujarat sample farmers expressed satisfaction that their overall welfare position improved by 37%. Uttar Pradesh farmers, despite perceiving increases in grain and fodder yields, felt that the welfare position improved by only 29%. Rajasthan sample farmers felt that their welfare position improved by only 16%. A majority of the sampled farmers in the three states also perceived an improvement in grain quality, fodder quality and reduced duration that helped them to increase their cropping intensity. The sampled farmers felt that the disease resistance of pearl millet improved by 25% to 40% and that the drought resistance also increased by 20% to 30%. In Gujarat, the sampled farmers responded that they reduced the pearl millet area by 18% due to increased yields. In Rajasthan and Uttar Pradesh, the sampled farmers indicated that they reduced the pearl millet area by 9% and 7%, respectively.

Table 6.37. Perceptions of sampled farmers about farm-level benefits of pearl millet technology compared to a decade ago.

Type of benefit	Benefits in		
	Gujarat (N=147)	Rajasthan (N=272)	Uttar Pradesh (N=144)
Percentage increase in grain yield/ha	42.47 (144)	30.85 (259)	93.96 (143)
Percentage increase in fodder yield/ha	37.53 (145)	26.45 (201)	44.86 (125)
% overall household welfare position increased	35.20 (144)	16.00 (144)	28.70 (135)
Better grain quality (Yes)	(144)	(228)	(119)
Better fodder quality (Yes)	(144)	(227)	(107)
Reduced duration leading to higher cropping intensity (Yes)	(146)	(203)	(88)
Resistance to diseases (Downy mildew)*	25.06 (145)	29.48 (102)	38.90 (137)
Tolerance to drought*	22.19 (146)	23.00 (218)	28.70 (135)
Percentage pearl millet area reduced per household	17.53 (125)	8.78 (206)	6.84 (85)

Figures in parenthesis indicate number of households acknowledging the benefits
* yields per ha improved or inputs saved due to new technology

6.20 Allocation of inputs to pearl millet cultivation

In Gujarat, there was no change in allocation of land to pearl millet cultivation (Table 6.38). However, since 2008, the expenditure on different inputs has gone up substantially. Since the new hybrids are yielding more, the input requirements have also gone up significantly. The prices of inputs have also increased rapidly. As a result, the expenditure on different inputs such as fertilizers, pesticides, farm machinery, soil and water conservation and irrigation have gone up. The seed rate has not increased but the prices charged by the companies for new hybrids have increased.

Table 6.38. Allocation of inputs to pearl millet cultivation in Gujarat.

Input allocation	Year of change	Old allocation	New allocation
Own land allocation (ha)	No change		
Leased in land allocation (ha)	No change		
Seed rate kg/ha	2008	7.98	5.68
Mechanization expenditure ₹ (US$)/ha	2008	7,558 (128.1)	10,868 (184.2)
Fertilizer application cost ₹ (US$)/ha	2008	3,363 (57.0)	5,865 (99.4)
Pesticide application cost ₹ (US$)/ha	2008	3,965 (67.2)	6,573 (111.4)
Irrigation expenditure ₹ (US$)/ha	2008	7,204 (122.1)	11,422 (193.6)
Soil & water conservation expenditure ₹ (US$)/ha	2008	3,127 (53.0)	5,310 (90.0)

In case of Rajasthan sample, there was no change in land allocation for pearl millet (Table 6.39). The seed rate has marginally decreased but the price of seed has increased. The mechanization expenditure has gone up by 56% since 2010. The fertilizer cost also went up by 52%. The pesticide cost increased by 53%. Irrigation expenditure recorded 36% increment over study time. Soil and water conservation expenditure also went up by 33%.

Table 6.39. Allocation of inputs to pearl millet cultivation in Rajasthan.

Input allocation	Year of change	Old allocation	New allocation
Own land allocation (ha)	No change	1.37	1.37
Leased in land allocation (ha)	No change	0.00	0.00
Seed rate kg/ha	2010	5.55	4.30
Mechanization expenditure ₹ (US$)/ha	2010	3,418 (57.9)	5,344 (90.6)
Fertilizer cost ₹ (US$)/ha	2010	986 (16.7)	1,496 (25.3)
Pesticide cost ₹ (US$)/ha	2010	2,424 (41.1)	3,713 (62.9)
Irrigation expenditure ₹ (US$)/ha	2010	6,418 (108.8)	8,708 (147.6)
Soil & water conservation expenditure ₹ (US$)/ha	2010	1,500 (25.4)	2,000 (33.9)

Since the cultivation of pearl millet is quite profitable, even the land allocation increased since 2010 (Table 6.40). Own land allocation increased by 27%, while the leased land allocation increased by 66%. The seed rate decreased marginally, but the price of seed is increasing year after year. The expenditure on machinery registered an increase of 129%. The fertilizer cost increased by 93%, while the plant protection cost has more than doubled. The irrigation expenditure went up by 79%. The soil and water conservation expenditure has actually trebled. While the prices of inputs have gone up quickly, farmers are also increasing the quantities of inputs used to reap higher yields.

Table 6.40. Allocation of inputs to pearl millet cultivation in Uttar Pradesh.

Input allocation	Year of change	Old allocation	New allocation
Own land allocation (ha)	2010	0.80	1.02
Leased in land allocation (ha)	2010	0.38	0.63
Seed rate kg/ha	2010	8.50	6.93
Mechanization expenditure ₹ (US$)/ha	2010	5,439 (92.2)	12,444 (211)
Fertilizer cost ₹ (US$)/ha	2010	1,425 (24.1)	2,752 (46.6)
Pesticide cost ₹ (US$)/ha	2010	458 (7.8)	875 (14.8)
Irrigation expenditure ₹ (US$)/ha	2010	3,920 (66.4)	7,028 (119.1)
Soil & water conservation expenditure ₹ (US$)/ha	2010	1,250 (21.2)	3,750 (63.5)

6.21 Issues of agricultural sustainability

The sample farmers in Gujarat felt that their agricultural production systems are sustainable over a long period of time. A large majority of the farmers felt that their allocation of land to food crops has increased and that their cropping intensity has also increased (Table 6.41). While they increased the use of inorganic fertilizers, plant protection chemicals and farm machines, they were also able to increase the use of organic manures due to increased number of livestock. They also opined that they were able to increase the soil and water conservation investments. However, they lamented that the average holding size is decreasing, due to which the area under green manures has also declined. The fertility status of land was perceived to be decreasing, while they were positive that the nutrient loss due to erosion has been arrested by the soil and water conservation methods employed. They responded that there was no change with respect to livestock population, availability of fodder, use of legumes in crop rotation, micro-nutrient application and frequency of soil testing. Overall, the farmers' perceptions about sustainability were largely positive.

Table 6.41. Perceptions of sample farmers about agricultural sustainability in Gujarat (N=147).

	% of HH perceiving the indicator		
Indicator	Increased	Constant	Decreased
Livestock population (No. per hh)	45.6	52.4	2.0
Availability of fodder/grazing pastures	36.7	61.9	1.4
Area under green manure crops	19.7	17.7	62.6
Land allocation for food crops (ha)	67.4	26.5	6.1
Average land holding size of farm (ha)	18.4	12.9	68.7
Land-use intensity (no. of crops per year)	80.3	14.3	5.4
Use of legumes in crop-rotations /inter-cropping	29.9	62.6	7.5
FYM/other organic matter application rate (qtl/ha/year)	85.7	12.9	1.4
Soil and water conservation investments per ha (private and public)	70.0	24.5	5.5
Soil loss due to erosion	14.3	15.0	70.7
Soil fertility status (organic carbon and NPK levels)	18.4	12.9	68.7
Inorganic fertilizers (N, P, K – application rate)	83.7	8.8	7.5
Micro-nutrient application (kg/ha)	33.3	58.5	8.2
Frequency of soil testing and use of fertilizers based on recommendations	33.3	59.2	7.5
Expenditure on plant protection chemicals (₹/ha)	87.8	8.2	4.0
Expenditure on farm mechanization (₹/ha)	92.5	6.8	0.7

The sample farmers in Rajasthan were also, in general, positive about sustainability (Table 6.42). They felt that the livestock population has increased and that the fodder supply has also improved. Although they are now using more fertilizers, plant protection chemicals and farm machines, they are also applying more farmyard manure to their fields. As a result, their soil fertility status has improved. They did not perceive any reduction in any sustainability parameter, including the average size of holding. A majority of them felt that all other parameters were constant. Not even a single indicator has worsened; the sustainability indicators have largely remained constant and some have shown improvement.

The response of the sample farmers regarding sustainability was mixed. The sample farmers felt that the size of holding has decreased and that they are not able to use legumes in crop rotation (Table 6.43). Despite an increase in livestock population, they are unable to increase the application of organic manures to their fields. Since they are not able to make sufficient investments on soil and water conservation, there is an increasing loss of soil fertility due to erosion. However, they were able to increase the livestock

Table 6.42. Perceptions of sample farmers about agricultural sustainability in Rajasthan (N=272).

	% of HH perceiving the indicator		
Indicator	Increased	Constant	Decreased
Livestock population (No. per hh)	66.2	26.1	7.7
Availability of fodder/grazing pastures	51.8	37.9	10.3
Area under green manure crops	11.0	61.8	27.2
Land allocation for food crops (ha)	14.3	72.8	12.9
Average land holding size of farm (ha)	4.4	71.7	23.9
Land-use intensity (no. of crops per year)	20.6	59.2	20.2
Use of legumes in crop-rotations /inter-cropping	24.3	57.7	18.0
FYM/other organic matter application rate (qtl/ha/year)	69.5	18.0	12.5
Soil and water conservation investments per ha (private and public)	20.2	58.5	21.3
Soil loss due to erosion	15.4	51.5	33.1
Soil fertility status (organic carbon and NPK levels)	63.2	17.6	19.1
Inorganic fertilizers (N, P, K – application rate)	62.5	23.5	14.0
Micro-nutrient application (kg/ha)	30.9	61.8	7.4
Frequency of soil testing and use of fertilizers based on recommendations	33.8	49.6	16.5
Expenditure on plant protection chemicals (₹/ha)	43.4	44.9	11.8
Expenditure on farm mechanization (₹/ha)	77.6	21.3	1.1

Table 6.43. Perceptions of sample farmers about agricultural sustainability in Uttar Pradesh (N=144).

	% of HH perceiving the indicator		
Indicator	Increased	Constant	Decreased
Livestock population (No. per hh)	81.3	9.0	9.7
Availability of fodder/grazing pastures	51.4	38.9	9.7
Area under green manure crops	14.6	46.5	38.9
Land allocation for food crops (ha)	51.4	24.3	24.3
Average land holding size of farm (ha)	5.6	28.5	66.0
Land-use intensity (no. of crops per year)	54.2	22.2	23.6
Use of legumes in crop-rotations /inter-cropping	11.1	22.9	66.0
FYM/other organic matter application rate (qtl/ha/year)	21.5	18.8	59.7
Soil and water conservation investments per ha (private and public)	42.4	30.6	27.1
Soil loss due to erosion	1.4	29.9	68.8
Soil fertility status (organic carbon and NPK levels)	32.6	33.3	34.0
Inorganic fertilizers (N, P, K – application rate)	80.6	18.1	1.4
Micro-nutrient application (kg/ha)	52.8	38.2	9.0
Frequency of soil testing and use of fertilizers based on recommendations	39.6	48.6	11.8
Expenditure on plant protection chemicals (₹/ha)	43.8	51.4	4.9
Expenditure on farm mechanization (₹/ha)	97.9	2.1	0.0

population and increase the supply of fodder resources. They could increase the cropping intensity due to which they had to increase the application of inorganic fertilizers and micro-nutrients. They were also able to increase the allocation of land to food crops. They are also using more machines due to labor shortages. All other parameters like area under green manure crops, frequency of soil testing and use of recommended fertilizers and use of plant protection chemicals remained constant. Overall, it may be judged that the sample farmers in Uttar Pradesh have expressed concerns about sustainability with respect to some critical factors.

6.22 Quality of land allocated to pearl millet

Coarse cereals such as pearl millet have lost areas to superior cereals like rice and wheat and other more profitable non-food crops. Increased irrigation facilities, rapid technical progress and favorable policies have caused these shifts. There was some evidence of farmers shifting good quality lands to more profitable crops and growing coarse cereal crops in marginal lands in some of the regions. We wanted to test whether the same phenomenon is in operation in the three study states of Gujarat, Rajasthan and Uttar Pradesh also. Farmers were asked how different qualities of land were allocated to different rainy season crops ten years ago and in 2013. These responses were analyzed and the results are presented in Table 6.44. The results did not lend support to the above hypothesis. There was no perceptible shift in the allocation of best quality land over the 10 years period in any of the study states. Pearl millet received best quality land in 60% to 70% of the cases in the three states. It also received about 20% to 25% of medium quality land and about 9% to 14% of the poor quality lands. Although pearl millet is not the most profitable crop, it is still valued as one of the staple foods, meeting the food requirements of the humans and feed demands of the livestock. Farmers do give priority to it in the allocation of land. The patterns of land allocation 10 years ago and in 2013 did not change at all and, hence, the hypothesis that pearl millet is being increasingly shifted to marginal lands is rejected.

Table 6.44. Allocation of different qualities of land to pearl millet.

State and quality of land	Allocation 10 years ago	Allocation at present
Gujarat		
Best quality	62.08	64.44
Medium quality	25.28	22.01
Poor quality	12.64	13.55
Rajasthan		
Best quality	70.20	68.93
Medium quality	20.70	21.90
Poor quality	9.10	9.33
Uttar Pradesh		
Best quality	66.10	69.15
Medium quality	21.81	23.26
Poor quality	12.06	7.60

Table 6.45. Shifting of pearl millet to poor quality land

State	Yes	No
Gujarat	23	124
Rajasthan	65	207
Uttar Pradesh	14	130
Total	**102**	**461**

The sampled farmers were also asked whether they shifted pearl millet to poor quality lands or not. In Gujarat, only 19% of the respondents answered the question in the affirmative. Their proportion was slightly higher at 31% in the Rajasthan sample, while it was much lower at 10% in Uttar Pradesh. In the total sample, only 22% of the respondents indicated that they shifted pearl millet to poor quality land. The remaining 78% of the sampled farmers denied any such shift. The results from Table 6.45 are lending some support to the perception that pearl millet is shifted to poor quality lands. There is a clash of perceptions. As per Table 6.44, farmers mentioned that they have not changed the allocation of different qualities of land to pearl millet. Yet, about 22% of sample farmers felt that they shifted pearl millet to poor quality land. This proportion is higher at 31% in case of Rajasthan. We can endorse that there is a trend of shifting pearl millet to poor quality land, especially in Rajasthan. In the other two states, this proportion is lower, and we do not have clinching evidence to conclude either way because the data presented in Table 6.44 is conflicting with that presented in Table 6.45.

6.23 Consumption of pearl millet grain

Another popular belief is that the farmers are shifting their consumption of cereals from coarse grains like pearl millet towards wheat and rice. In North Gujarat, where pearl millet is the staple food, farmers answered that they have increased the consumption of pearl millet over the last 10 years from 48.78 kg to 63.82 kg per month (Table 6.46). On the contrary, in Rajasthan and Uttar Pradesh, the sampled farmers have reduced the consumption of pearl millet over time. In the consumption expenditure data also, sampled farmers spent more on wheat than on pearl millet in these two states. In Rajasthan, the consumption decreased from 35.01 kg per month to 27.85 kg per month over a 10-year period. In Uttar Pradesh, the consumption decreased from 24.23 kg to 19.09 kg during the survey period. At the aggregate level of the sample, the average consumption remained stable at about 36 kg per month in all the three time periods. The results are inconclusive, with the consumption increasing in Gujarat sample and decreasing in the other two states. At the aggregate sample level, the data points to no change in the monthly consumption of pearl millet per month.

Table 6.46. Perceived consumption of pearl millet grain (kg per household).

State	Consumption (10 yrs ago)	Consumption (5 yrs ago)	Consumption (Present)
Gujarat	48.78	55.00	63.82
Rajasthan	35.01	31.35	27.85
Uttar Pradesh	24.23	21.08	19.09

6.24 Contribution of pearl millet to fodder resources

The contribution of pearl millet to feed resources in the three states is presented in Table 6.47. Pearl millet contributed to 82% of the fodder needs of the sampled farmers in Gujarat. They depended on sorghum fodder and wheat straw to meet the balance of the fodder needs. In Rajasthan, pearl millet fodder provided only 37% of the total fodder requirements of the sample farmers. The alternative fodders like sorghum fodder, wheat and barley straws and lucerne green fodder are helping the farmers to meet the balance fodder requirements. In Uttar Pradesh, the contribution of pearl millet fodder to the fodder needs is only 15.4%. They depend on the dry fodder of wheat and barley and the green fodder of sorghum and berseem to meet the remaining 85% of the fodder requirements.

Table 6.47. Importance of pearl millet fodder in feeding livestock.

State	Percentage of fodder needs met by PM	Alternative fodder sources available
Gujarat	82.03	Sorghum, wheat straw
Rajasthan	37.21	Sorghum, wheat, barley and lucerne
Uttar Pradesh	15.40	Wheat, barley and sorghum straws and berseem

6.25 Preferred traits of grain and fodder of pearl millet

The sampled farmers were asked to indicate the grain and fodder traits they would like to see in the new hybrids. Their responses are furnished in Table 6.48. Gujarat farmers preferred hybrids with big sized grain. They also laid stress on better grain quality and preferred greenish color. Very few of the Gujarat sample stressed on high yield. In Rajasthan, the stress was on higher yield. More than half of the farmers laid emphasis on better grain quality. A few farmers wanted disease resistance to be incorporated into the new varieties. In Uttar Pradesh also, more than two-thirds of the farmers wanted the new hybrids to give even higher yields than the available hybrids. A few farmers wanted shorter duration and disease resistance to be incorporated in to the new hybrids.

With respect to the fodder traits, Gujarat farmers wanted hybrids with thin stem. More than half the farmers wanted high yield of fodder to be incorporated into the new hybrids. Other traits emphasized by them were keeping quality, height and better quality. In case of the Rajasthan sample, the emphasis was on high yield and better quality of fodder (Kelley et al. 1996). Uttar Pradesh farmers also favored better quality, thin stem, green fodder quality and high yield to be incorporated into new hybrids.

Table 6.48 No. of farmers preferring different grain and fodder traits of pearl millet.

Traits	Gujarat	Rajasthan	Uttar Pradesh
Grain			
High yield	17	272	105
Better quality	97	147	32
Less duration			4
Disease resistance		5	3
Preferred color	87		
Big sized grain	147		
Others			
Fodder			
High yield	74	272	3
Better quality	4	201	67
Use as green fodder			9
Thin stem	147		18
Height	14		
Keeping quality	41		

Chapter 7

Summary and conclusions

Pearl millet is a staple food crop of the economically backward living in areas of low rainfall and shallow soils in Africa and Asia. It is the sixth most important food crop in the world. While the area under millets is decreasing globally, it has niche areas of production and consumption in semi-arid and arid parts of the world, particularly in sub-Saharan Africa. In India, the area under pearl millet decreased from 9.1 million ha in 1950-51 to 7.3 million ha in 2014-15 but its production increased from 2.6 million tons in 1950-51 to 9.18 million tons in 2014-15 due to rapid increases in productivity. After introduction of some improved straight and composite varieties, the All India Coordinated Research Program on Pearl Millet of the Indian Council of Agricultural Research (ICAR) came out with hybrids to achieve quantum jumps in productivity. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), which was set up in 1972, made use of the wide germplasm it has collected and developed composites and hybrids with strong resistance to downy mildew, high yield and better quality. Over the years, the leadership in seed marketing gradually moved from the public-sector agencies to private seed companies. ICRISAT collaborated with both private- and public-sector companies to help them develop and market improved varieties and hybrids to reach the farmers effectively through the wide network of private seed shops in the country.

ICRISAT established the Hybrid Parents Research Consortium (HPRC) in 2000 with a view to engage the private sector in a more active way and boost the pace and scale of impacts. Under this Public-Private Partnership (PPP) arrangement, private seed companies which join as members will contribute an annual fee and receive parent materials, A- lines and R- lines which can be used immediately in their breeding programs to develop hybrids with market preferred traits and reach farmers quickly. Nearly 40 private seed companies have joined HPRC pearl millet and received benefit from the PPP arrangements during different phases (2000-04, 2005-09, 2010-13 and 2014-17) of HPRC. ICRISAT conducted a study to assess the contribution of HPRC-PM between 2000 and 2010 by sending questionnaires to the members of HPRC. Twenty private seed company members responded to the survey conducted by a social scientist and plant breeder. Thirteen seed companies have developed and marketed a large number of hybrids and popularized them. Public sector seed companies also developed a number of hybrids. After having established by the HPRC-1 survey that HPRC-PM has made substantial contributions, ICRISAT commissioned the present study with the following objectives:

- To assess the coverage of pearl millet area by the hybrids developed by the private seed companies and NARS using the ICRISAT-bred parent materials during 2000-2010.
- To measure the impact of hybrids with ICRISAT-bred parental lines on grain and fodder yields of the pearl millet farmers by comparing them with those of the hybrids replaced by them and with those of the hybrids developed by private seed companies and research institutions without using the ICRISAT parent materials.
- To compute the incremental benefit-cost ratios accruing to farmers by the adoption of hybrids marketed by companies that made use of the parent materials supplied by ICRISAT.

Three important states for pearl millet in India – Rajasthan, Gujarat and Uttar Pradesh – were strategically selected for this study. Rajasthan has the highest area under pearl millet, while Gujarat and Uttar Pradesh have achieved fairly high levels of yields by universally adopting hybrids/improved cultivars. The seed company members were requested to provide the marketing data of different hybrids; they cooperated by giving the required information. A perusal of the market data helped in locating the important seed markets and districts for the cultivation of major hybrids in the three study states. Based on seed sales data and crop spread, North Gujarat, East Rajasthan and West Uttar Pradesh were purposively selected for the field survey. Since Rajasthan has the highest quantity of hybrid seed marketed, it was decided to assign 50% of the sample to that state. Gujarat and Uttar Pradesh were assigned 25% of the sample each. Banaskantha, Patan and Mehsana districts in North Gujarat, Jaipur, Dausa, Alwar and Sikar districts from East Rajasthan and Agra, Firozabad and Mahamaya Nagar (Hathras) districts from West Uttar Pradesh were

further selected. After discussing with the research scientists, agricultural department officers and Krishi Vigyan Kendras (KVKs) in the selected districts, tehsils, villages and farmers were selected to represent the farmers growing pearl millet in the rainy season at these locations. Finally, a total sample of 563, with the breakup of 272 from Rajasthan, 147 from Gujarat and 144 from Uttar Pradesh, was selected. The field survey was conducted between January and April 2014 after initial selection and training of the investigators, followed by pre-testing and refinement of questionnaires. The data were verified and validated before they were entered and analyzed. The important findings from the study are summarized below.

The sample farmers were largely in their forties with about two to three decades of farming experience and pearl millet growing. The samples of Gujarat and Uttar Pradesh were dominated by forward communities while backward castes had a large representation in the Rajasthan sample. The representation of scheduled castes, scheduled tribes and nomadic tribes was limited to less than 10% in the sample. The households were predominantly headed by males. They had about seven to eight years of schooling. The size of the family was small (5.63) in Gujarat and was quite high in Uttar Pradesh (8.83), with Rajasthan falling in between (7.56). All the sample farmers primarily depended upon farming for their sustenance with supplementary incomes from livestock rearing, farm and non-farm labor, salary and business incomes providing useful contributions.

The size of holding was the largest in the Gujarat sample and the smallest in the Uttar Pradesh sample with the Rajasthan sample having landholdings in between the other two. The irrigation coverage was also the highest in Gujarat and lowest in Uttar Pradesh. Rajasthan had medium irrigation coverage. Despite larger area and higher irrigation coverage, land values were the lowest in Gujarat. Uttar Pradesh sample reported higher land values and better productivity due to high rainfall and fertile soils. Rajasthan occupied the middle position both with respect to the land values as well as productivity. The asset values of sample farmers in Uttar Pradesh were about two times that of Gujarat sample, mainly on account of land value. The Rajasthan sample had higher asset values than the Gujarat sample but lower values than the Uttar Pradesh sample. There was not much difference between the farmers of the three states with respect to non-land assets like livestock, farm equipment, consumer durables and farm buildings.

In all the three states, a large number of private seed companies are marketing their seeds. Coverage by hybrids was universal in Gujarat, while Uttar Pradesh has very little area under local varieties. Rajasthan has considerable area under local varieties. Both HPRC hybrids as well as non-HPRC hybrids were competing in the markets of the three states. Wherever the sampled farmers were not able to identify the company or the brand name of the hybrid, they were categorized under non-HPRC hybrids. Non-HPRC hybrids had an edge over the HPRC hybrids in terms of area coverage in Rajasthan, while HPRC hybrids dominated the area both in Gujarat and Uttar Pradesh sample. The share of HPRC hybrids in the total sample increased between 2011-12 and 2013-14 and reached 59.5% by 2013-14. The rest of pearl millet cropped area is covered with non-HPRC hybrids released in these three states and local cultivars.

The first adoption pattern of important HPRC and non-HPRC hybrids were studied based on the year of introduction, the year in which they attained peak level of first adoption and the cumulative adoption figures. While many hybrids were in the market during different years, only some have gained market acceptance and were popular during the three years before the survey, 2011-12, 2012-13 and 2013-14. The patterns of first adoption across states revealed that the initial adoption lag to reach the peak level of adoption was estimated at 4-5 years. The hybrids exclusively preferred by farmers were sustained in the market for about 9-10 years. In Gujarat, HPRC hybrids occupied 71% share in 2011-12, 76% share in 2012-13 and 78% share in 2013-14. In Rajasthan, HPRC hybrids covered 47.7% area in 2011-12, 45.7% in 2012-13 and 48.9% in 2013-14. Local varieties covered around 4% of the pearl millet area in Rajasthan. In Uttar Pradesh, HPRC hybrids occupied 56.9% area in 2011-12, 57.5% area in 2012-13 and 66.9% area in 2013-14. Overall, HPRC hybrids covered 56.0% in 2011-12, 56.2% in 2012-13 and 59.5% in 2013-14. While local varieties maintained about 4.5% share in the pearl millet area throughout, the share of non-HPRC hybrids came down from 38.3% in 2011-12 to 36.0% in 2013-14. Thus, HPRC hybrids were seen to be increasing their share over the years and came close to two-thirds of area by 2013-14.

The profitability of HPRC hybrids was compared with that of the hybrids replaced by them. While the hybrids replaced by the HPRC hybrids could just break even, HPRC hybrids were able to give benefit-cost ratios ranging between 1.3 and 1.4. The cost of cultivation was worked out separately for HPRC hybrids and non-HPRC hybrids. The cost of cultivation was higher for non-HPRC hybrids in Gujarat, while it was higher in case of HPRC hybrids in Rajasthan and Uttar Pradesh. In all the three states, the grain and fodder yields were higher in case of HPRC hybrids. The benefit-cost ratios were much higher for HPRC hybrids in all the three states than for the non-HPRC hybrids. The unit cost of production was lower for HPRC hybrids by US$3.46 per quintal in Gujarat, US$2.49 per quintal in Rajasthan and US$1.97 per quintal in Uttar Pradesh. The total benefits on account of HPRC hybrids were worked out as US$39.5 million in Gujarat, US$55.2 million in Rajasthan and $39.0 million in Uttar Pradesh. The total benefits due to HPRC hybrids in the three study states added up to US$133.7 million per year. If the benefits are projected for the whole country, the benefits from HPRC hybrids could perhaps surpass US$150 million per year.

Although pearl millet cultivation has been profitable in all the three states, its economics have to be compared with the other crops competing for area in the rainy season. In Gujarat, pearl millet was more profitable than cluster bean, but it was less profitable than bottle gourd. In Rajasthan, pearl millet was more profitable than cluster bean, but was less profitable than groundnut and cotton. In Uttar Pradesh, pearl millet was only more profitable than maize but was less profitable when compared to sorghum fodder and cluster bean. Since pearl millet is able to recover all the costs and stands profitable than some of the competing crops, it is able to retain considerable area under it.

The annual household income of sample households was the highest in Uttar Pradesh (US$3418) and lowest in Rajasthan (US$1564), with Gujarat (US$1691) falling in between. In Gujarat and Uttar Pradesh, farming is able to provide about 50% of the total income. But in the Rajasthan sample, farming provided only 30% of the household income. Livestock rearing, salaried income, non-farm employment, etc., are the supplementary sources of income. The annual household expenditure was the highest in Uttar Pradesh (US$1693) and lowest in Gujarat (US$1260), with Rajasthan ($1500) occupying the middle position. However, the per capita expenditure is the highest in Gujarat at US$223.80 because of the small sized family. It is lower in Rajasthan at US$198.41 and lowest in Uttar Pradesh at US$191.73. In terms of per capita expenditure per day, all the sampled farmers spend less than a dollar per day and fit in to the definition of the World Bank as very poor. Food expenditure had about 60% share in the household expenditure. The expenditure on pearl millet was the highest among the cereals only in Gujarat. In the other two states, the expenditure on wheat was higher than that on pearl millet.

In all the three states, most of the sampled farmers endorsed that pearl millet production technology benefited them in many ways. Both the grain and fodder yield as well as their quality were acknowledged to have increased substantially. They have also perceived that their overall welfare position has improved because of hybrid technology. They also endorsed that the duration of the hybrids has decreased and the disease resistance has improved in the new hybrids. However, the input requirements of fertilizer, plant protection, irrigation, mechanization and investments on soil and water conservation have increased substantially because of the hybrid technology. The indicators of sustainability have improved in case of the Gujarat and Rajasthan samples, but have deteriorated slightly in case of the Uttar Pradesh sample. It was found that pearl millet continues to receive the allocation of same good quality land as it was receiving 10 years ago. However, about 31% of the Rajasthan sample perceived that pearl millet is gradually being shifted to poorer quality lands. It was noted that pearl millet consumption has increased in Gujarat over the last 10 years, but has decreased in the other two states. In Gujarat, pearl millet is supplying about 82% of the fodder requirements but its share is only 37% in Rajasthan and 15% in Uttar Pradesh.

Sampled farmers are looking forward in the new hybrids to still higher yields, better quality of grain, thin stem, big grain size, preferred color of grain and disease resistance. The fodder traits preferred by the sampled farmers included high yield, better quality, stay-green nature, suitability for green fodder, disease resistance and keeping quality. Farmers have asked for policies that will reduce the cost of cultivation and increase the MSP for pearl millet.

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Annexures

Annexure 1. Hybrid-wise details and their extent of involvement with ICRISAT parental lines during 2000-2010.

Seed company no.	HPRC hybrid no.	HPRC hybrid code no.	Season intended	Marketed year	No. of years in the market	With IC-bred lines	Without IC-bred lines
SC-01	1	SC-01-hyb 1	Rainy	2011	1	Yes	
	2	SC-01-hyb 2	Summer	2008	3	Yes	
	3	SC-01-hyb 3	Rainy	2007	4	Yes	
	4	SC-01-hyb 4	Rainy	2006	3	Yes	
	5	SC-01-hyb 5	Rainy	2004	3	Yes	
SC-02	6	SC-02-hyb 1*	Rainy & Summer	2010	1	Yes	
	7	SC-02-hyb 2	Rainy	2009	2	Yes	
	8	SC-02-hyb 3	Rainy	2009	2	Yes	
	9	SC-02-hyb 4	Rainy & Summer	2006	6	Yes	
	10	SC-02-hyb 5	Rainy & Summer	2003	9	Yes	
	11	SC-02-hyb 6	Rainy	1996	5	Yes	
	12	SC-02-hyb 7	Rainy	1994	10	Yes	
	13	SC-02-hyb 8	Rainy	1992	10	Yes	
	14	SC-02-hyb 9	Rainy	1990	5	Yes	
SC-03	15	SC-03-hyb 1	Rainy	2010	1	Yes	
	16	SC-03-hyb 2	Rainy	2008	2	Yes	
	17	SC-03-hyb 3	Rainy	2008	1	Yes	
	18	SC-03-hyb 4	Summer	2006	4	Yes	
	19	SC-03-hyb 5	Rainy	2006	4	Yes	
	20	SC-03-hyb 6	Rainy	2008	4	Yes	
	21	SC-03-hyb 7	Rainy	1995	16	Yes	
SC-04	22	SC-04-hyb 1	Rainy & Summer	2007	4	Yes	
	23	SC-04-hyb 2	Rainy	2008	3	Yes	
	24	SC-04-hyb 3	Rainy	2006	5	Yes	
	25	SC-04-hyb 4+	Rainy	2005	1	Yes	
		SC-04-hyb 5	Rainy	2004	1		Yes
SC-05		SC-05-hyb 1	Rainy & Summer	2010	1		Yes
		SC-05-hyb 2	Rainy	2009	2		Yes
		SC-05-hyb 3	Rainy & Summer	2007	4		Yes
		SC-05-hyb 4	Rainy	2003	7		Yes
SC-06**		-	-	-	-	-	-
SC-07		SC-07-hyb 1	Rainy & Summer	2008	1		Yes
		SC-07-hyb 2	Rainy	2010	2		Yes
		SC-07-hyb 3	Rainy	2007	5		Yes
		SC-07-hyb 4	Rainy	2006	4		Yes
SC-08	26	SC-08-hyb 1	Rainy & Summer	2010	1	Yes	
	27	SC-08-hyb 2	Rainy	2008	4	Yes	
	28	SC-08-hyb 3	Rainy	2007	3	Yes	

Continued

Annexure 1. *Continued*

Seed company no.	HPRC hybrid no.	HPRC hybrid code no.	Season intended	Marketed year	No. of years in the market	With IC-bred lines	Without IC-bred lines
	29	SC-08-hyb 4	Rainy	2006	6	Yes	
	30	SC-08-hyb 5	Rainy & Summer	2004	3	Yes	
	31	SC-08-hyb 6	Rainy	2002	3	Yes	
	32	SC-08-hyb 7	Rainy & Summer	2002	3	Yes	
SC-09	33	SC-09-hyb 1	Rainy	NA	NA	Yes	
		SC-09-hyb 2	Rainy & Summer	1992	20		Yes
	34	SC-09-hyb 3	Rainy	1995	17	Yes	
SC-10	35	SC-10-hyb 1	Rainy	2008	4	Yes	
	36	SC-10-hyb 2	Rainy	2008	4	Yes	
	37	SC-10-hyb 3	Post-rainy	2006	6	Yes	
	38	SC-10-hyb 4	Summer	2005	7	Yes	
	39	SC-10-hyb 5	Summer	2002	9	Yes	
	40	SC-10-hyb 6	Rainy & Summer	2002	9	Yes	
SC-11		SC-11-hyb 1	Rainy	2010	2		Yes
	41	SC-11-hyb 2	Rainy	2007	5	Yes	
		SC-11-hyb 3	Rainy & Summer	2005	7		Yes
	42	SC-11-hyb 4	Rainy & Summer	2004	8	Yes	
SC-12	43	SC-12-hyb 1	Rainy	2010	2	Yes	
	44	SC-12-hyb 2	Rainy	2010	2	Yes	
	45	SC-12-hyb 3	Rainy	2010	2	Yes	
	46	SC-12-hyb 4	Rainy & Summer	2008	4	Yes	
	47	SC-12-hyb 5	Rainy & Summer	2004	8	Yes	
	48	SC-12-hyb 6	Rainy	2003	8	Yes	
	49	SC-12-hyb 7	Rainy	1997	11	Yes	
	50	SC-12-hyb 8	Rainy	1998	9	Yes	
	51	SC-12-hyb 9	Rainy	1995	13	Yes	
SC-13		SC-13-hyb 1	Rainy	2010	2		Yes
		SC-13-hyb 2	Rainy	2010	2		Yes
		SC-13-hyb 3	Rainy	1985	26		Yes
		SC-13-hyb 4	Rainy & Summer	2007	4		Yes
	52	SC-13-hyb 5	Rainy	1997	15	Yes	
	53	SC-13-hyb 6	Rainy & Summer	1997	15	Yes	
	54	SC-13-hyb 7	Rainy	2005	2	Yes	
	55	SC-13-hyb 8	Rainy	2000	10	Yes	
	56	SC-13-hyb 9	Rainy	2000	10	Yes	
SC-14	57	SC-14-hyb 1	Rainy	2008	4	Yes	
	58	SC-14-hyb 2	Summer	2008	4	Yes	
	59	SC-14-hyb 3	Rainy	2005	6	Yes	
SC-15	60	SC-15-hyb 1	Rainy	2011	1	Yes	
	61	SC-15-hyb 2	Rainy & Summer	2007	4	Yes	

Continued

Annexure 1. *Continued*

Seed company no.	HPRC hybrid no.	HPRC hybrid code no.	Season intended	Marketed year	No. of years in the market	With IC-bred lines	Without IC-bred lines
	62	SC-15-hyb 3	Rainy	2007	4	Yes	
	63	SC-15-hyb 4	Rainy & Summer	2006	5	Yes	
	64	SC-15-hyb 5	Rainy	2005	6	Yes	
	65	SC-15-hyb 6	Rainy & Summer	2003	8	Yes	
	66	SC-15-hyb 7	Rainy & Summer	2002	9	Yes	
	67	SC-15-hyb 8	Rainy & Summer	2001	7	Yes	
SC-16		SC-16-hyb 1	Rainy	2010	2		Yes
		SC-16-hyb 2	Rainy & Post-rainy	2008	4		Yes
		SC-16-hyb 3	Rainy & Post-rainy	2008	4		Yes
		SC-16-hyb 4	Rainy & Post-rainy	2008	2		Yes
SC-17		SC-17-hyb 1	Rainy	2008	4		Yes
		SC-17-hyb 2	Rainy	2006	4		Yes
		SC-17-hyb 3	Rainy	2006	6		Yes
		SC-17-hyb 4	Rainy	2004	3		Yes
SC-18		SC-18-hyb 1	Rainy	2008	4		Yes
		SC-18-hyb 2	Summer	2008	4		Yes
		SC-18-hyb 3	Rainy	2008	4		Yes
SC-19		SC-19-hyb 1	Rainy	2010	2		Yes
SC-20		SC-20-hyb 1	Rainy & Summer	2005	6		Yes
	68	SC-20-hyb 2	Rainy & Summer	2009	2	Yes	
		SC-20-hyb 3	Rainy & Summer	2007	3		Yes
		SC-20-hyb 4	Rainy & Summer	2000	5		Yes
		SC-20-hyb 5	Summer	2000	5		Yes
		SC-20-hyb 6	Rainy & Summer	2000	2		Yes
	69	SC-20-hyb 7	Rainy & Summer	2008	NA	Yes	
SC-21		SC-21-hyb 1	Rainy	2010	1		Yes
	70	SC-21-hyb 2	Rainy	2009	2	Yes	
	71	SC-21-hyb 3	Rainy	2004	7	Yes	

* includes one fodder hybrid + improved ** recently initiated the breeding program

List of other HPRC hybrids developed by previous HPRC members during 2000-2010.

PSC code	HPRC hybrid no.	HPRC hybrid code no.	With IC-bred lines	Without IC-bred lines
PSC-01	72	PSC-01 hyb 1	Yes	
	73	PSC-01 hyb 2	Yes	
PSC-02	74	PSC-02 hyb 3	Yes	
PSC-03	75	PSC-03 hyb 4	Yes	
PSC-04	76	PSC-04 hyb 5	Yes	
	77	PSC-04 hyb 6	Yes	
PSC-05	78	PSC-05 hyb 7	Yes	
	79	PSC-05 hyb 8	Yes	
PSC-06	80	PSC-06 hyb 9	Yes	

Annexure 2. List of NHPRC hybrids observed in the study area.

S.no.	Code no.	NHPRC hybrid no.	Remarks
1	SC-04	NHPRC 01	Present HPRC member
2	SC-05	NHPRC 02	Present HPRC member
3	SC-05	NHPRC 03	Present HPRC member
4	SC-05	NHPRC 04	Present HPRC member
5	SC-05	NHPRC 05	Present HPRC member
6	SC-07	NHPRC 06	Present HPRC member
7	SC-07	NHPRC 07	Present HPRC member
8	SC-07	NHPRC 08	Present HPRC member
9	SC-07	NHPRC 09	Present HPRC member
10	SC-09	NHPRC 10	Present HPRC member
11	SC-11	NHPRC 11	Present HPRC member
12	SC-11	NHPRC 12	Present HPRC member
13	SC-13	NHPRC 13	Present HPRC member
14	SC-13	NHPRC 14	Present HPRC member
15	SC-13	NHPRC 15	Present HPRC member
16	SC-13	NHPRC 16	Present HPRC member
17	SC-16	NHPRC 17	Present HPRC member
18	SC-16	NHPRC 18	Present HPRC member
19	SC-16	NHPRC 19	Present HPRC member
20	SC-16	NHPRC 20	Present HPRC member
21	SC-17	NHPRC 21	Present HPRC member
22	SC-17	NHPRC 22	Present HPRC member
23	SC-17	NHPRC 23	Present HPRC member
24	SC-17	NHPRC 24	Present HPRC member
25	SC-18	NHPRC 25	Present HPRC member
26	SC-18	NHPRC 26	Present HPRC member
27	SC-18	NHPRC 27	Present HPRC member
28	SC-19	NHPRC 28	Present HPRC member
29	SC-20	NHPRC 29	Present HPRC member
30	SC-20	NHPRC 30	Present HPRC member
31	SC-20	NHPRC 31	Present HPRC member
32	SC-20	NHPRC 32	Present HPRC member
33	SC-20	NHPRC 33	Present HPRC member
34	SC-21	NHPRC 34	Present HPRC member
35	SC-22	NHPRC 35	Not a HPRC member
36	SC-23	NHPRC 36	Not a HPRC member
37	SC-24	NHPRC 37	Not a HPRC member
38	SC-25	NHPRC 38	Not a HPRC member
39	SC-26	NHPRC 39	Not a HPRC member
40	SC-27	NHPRC 40	Not a HPRC member

Continued

Annexure 2. *Continued*

41	PSC-06	NHPRC 41	Previously HPRC member
42	PSC-06	NHPRC 42	Previously HPRC member
43	SC-28	NHPRC 43	Not a HPRC member
44	SC-29	NHPRC 44	Not a HPRC member
45	SC-30	NHPRC 45	Not a HPRC member
46	SC-34	NHPRC 46	Not a HPRC member
47	SC-34	NHPRC 47	Not a HPRC member
48	SC-31	NHPRC 48	Not a HPRC member
49	SC-32	NHPRC 49	Not a HPRC member
50	SC-33	NHPRC 50	Not a HPRC member
51	SC-34	NHPRC 51	Not a HPRC member
52	NARS-06	NHPRC 52	NARS partner
53	NARS-02	NHPRC 53	NARS partner
54	NARS-07	NHPRC 54	NARS partner
55	SC-35	NHPRC 55	Not a HPRC member
56	SC-19	NHPRC 56	Present HPRC member
57	SC-36	NHPRC 57	Not a HPRC member

Annexure 3. Pearl millet hybrids developed and released by different NARS organizations using ICRISAT-bred materials during 2000-2010.

Code no.	Hybrid name	Season intended	Marketed year	No. of years in the market	With IC-bred lines	Without IC-bred lines
NARS 1	GHB 757	Rainy	2007	3	Yes	
	GHB 744	Rainy	2007	3	Yes	
	GHB 732	Rainy & Summer	2007	3	Yes	
	GHB 719	Rainy	2006	4	Yes	
	GHB 538	Rainy, Post-rainy & Summer	2004	6	Yes	
	GHB 577	Rainy	2003	7		Yes
	GHB 526	Post-rainy & Summer	2002	8	Yes	
	GHB 558	Rainy & Summer	2002	8	Yes	
NARS 2	HHB 226	Rainy		1	Yes	
	HHB 223	Rainy		2	Yes	
	HHB 216	Rainy		2		Yes
	HHB 197	Rainy		4	Yes	
	HHB 67 imp	Rainy		6	Yes	
	HHB 117	Rainy		7		Yes
	HHB 146	Rainy		8	Yes	
	HHB 94	Rainy		11	Yes	
NARS 3	SHANTI	Rainy	2006	5		Yes
	SABURI	Rainy	1995	15		Yes
	SHRADDHA	Rainy	1990	20		Yes
NARS 4	RHB 173	Rainy	2010	1	Yes	
	RHB 177	Rainy	2010	1	Yes	
	RHB 154	Rainy	2009	2	Yes	
	RHB 127	Rainy	2003	-	Yes	
	RHB 121	Rainy	2001	10	Yes	
	RHB 90	Rainy	2000	11	Yes	

Note: NARS-5 did not furnish the data.
NARS-1: Pearl Millet Research Station, Jamnagar, JAU, Gujarat
NARS-2: CCS Haryana Agricultural University, Hisar, Haryana
NARS-3: Bajra Research Station, Dhule, MPAU, Rahuri, Maharashtra
NARS-4: Agricultural Research Station, Durgapura, SKRAU, Bikaner, Rajasthan

Annexure 4. Survey instrument.

Pearl millet Technology Adoption and Impact Study in India

1. (HPRC-II Study) Household Survey Questionnaire for reference year, 2013-14

Particulars	ANSWERS	CODE/ID
Name		
S/o or D/o or W/o		
Village		
Taluka		
District		
State		
Mobile		

1.1. Household Information

Main occupation: ---------- Subsidiary occupation: ----------

Caste category: ---------- (SC/ST/OBC/NT/SBC/OC)

No. of years of farming: ---------- No. of years of pearl millet growing: ---------- (Yrs)

Number of Family Members: Male---------- Female---------- Children----------

Number of workers in Family: Male ---------- Female---------- Children (12 to 18 years old) ------

1.2. Landholding details in 2013-14 (in acres)

Type	Owned	Leased/shared-in	Leased/shared-out	Permanent Fallow	Operated
Wetland					
Dryland					
Grazing land					
Total					

** Operated = (Own land+ Leased-in/shared-in) – (Leased-out/shared-out+permanent fallow)

1.3. Cropping pattern (details of CY 2013-14 Kharif crops in acres)

Plot code	Owner ship*	Name of the crop	Proportion	Variety**	Specify name	Cropped area	Irrigated area	Main Production (kg)	Price/ kg	By-product (qtl)	Price/ qtl

1.4 Cropping pattern (details of CY 2013-14 Rabi crops in acres)

Plot code	Owner ship*	Name of the crop	Prop-ortion	Variety**	Specify name	Cropped area	Irrigated area	Main Production (kg)	Price/ kg	By-product (qtl)	Price/ qtl

1.5 Summer crops (if any proposed)

* Use the codes. Own land (OW), Leased-in (LI), leased-out (LO), Shared-in (SI), and Shared-out (SO)
** 1. Local 2. Improved 3.Hybrid 4.Bt

1.6 Details of household assets (As on July 2013)

Resources	Quantity	Unit price	Total value
1.6.1 Land (Acres)			
1. Irrigated land			
2. Dry land			
3. Grazing/Fallow land			
1.6.2 Livestock (Number)			
1. Draft animals			
2. She buffaloes			
3. Cows			
4. Young cattle			
5. Goats/sheep			
6. Poultry/others			
1.6.3 Farm Equipment (Number)			
1. Tractor with attachments			
2. Threshers/Power tillers			
3. Electric motors/oil engines			
4. Sprinkler sets/Drip irrigation			
5. Modern plough/seed drill, etc.			
6. Power or manual sprayer/duster			
7. Bullock cart and other implements			
1.6.4 Farm Buildings			
1. Residential house including courtyard			
2. Farm house including cattle shed			
3. Residential plots (if any)			
4. Others			
1.6.5 Consumer Durables			
1. Gold and Silver			
2. Auto/Two wheelers			
3. Fridge/television/washing machine			
4. Fan/Radio/Tape recorder, etc.			
5. Cooking gas (LPG)			
6. Mobile phones /Landline			
7. Furniture and utensils			

2. Adoption of pearl millet improved cultivars

2.1 In general, which is your preferred cultivar group in pearl millet cultivation?

----------(local/improved/hybrid)

2.2 Reasons :----------

2.3 First adoption of improved cultivars and sources of seed (Emphasis on pearl millet since 2001-02 only)

Improved Varieties known Use Annex	Year Variety was known first	Main source of variety information (Codes A)	Ever planted this variety? (Codes B)	If No, why ? (Codes C)	If YES, year first planted ?	Area first planted (acres)	How long you have grown this variety ?	First seed details: Main source of first seed (Codes D)	First seed details: Means of acquiring first seed (Codes E)	Allocation of area in 2013-14 Kharif under this variety (acres)

Codes A	Codes B	Codes C	Codes D	Codes E
Govt. Extension	Yes	Didn't get seed	1. Research PVS/Univ.	1. Gift/Free
Farmer Association	No	Lack of cash to buy	2. Extension demo plots	2. Borrowed seed
NGO		Poor taste	3. Farmer club/villagers	3.Bought with cash
Research center/Univ.		Low yielding	4. Local seed producers	4. Exchange with other seeds
On farm trials/demos		Require more rainfall	5. Local trader or agro-dealers	5. Others ----------
Fellow farmer		Expensive seed cost	6. Farmer to farmer seed exchange (relative, friend, etc)	
Private shop		Poor price	7. NGOs	
Newspaper/radio/TV		Long duration	8. Government agency	
Others --------		Labor scarcity	9. Inherited from family	
		10.Low fodder quantity	10. Other (specify)……	
		11.Others ----------		

2.4 Reasons for growing pearl millet

Reason	Weight out of 100
Fodder purpose	
Grain purpose	
Suitable to soil and climate	
Crop rotation	

2.5 How often do you grow pearl millet on same land (crop rotation)? (……..)

(a) Every year (b) Once in two years (c) Once in three years (d) Others (specify).....

2.6 Area allocation under pearl millet during the last three years? ---------- (I/D/C)

2.7 What is the alternate crop that you can grow on the land normally allocated to pearl millet?

2.8 Sources of seeds in 2013-14 planting (major two crops including pearl millet)

Crop	Variety	Source-1	Source-2	Source-3
Pearl millet				
Crop-2.....				

1. Research PVS/Univ.	5. Bought from local trader or seed companies	9. Own seed
2. Extension demo plots	6. Farmer to farmer seed exchange (relative, friend, etc)	10. Subsidized government seed supply
3. Farmer club/villagers	7.Provided free by NGOs	11. Other, specify……
4. Bought from local seed producers	8. Provided free by government agency	12. None

2.9. Allocation of pearl millet area under different cultivars in the last three years?

	Area pearl millet sown in acres		
Cultivars	Area in 2013-14	Area in 2012-13	Area in 2011-12
1.			
2.			
3.			
4.			
5.			

2.10. Pearl millet cultivar replacement during last six years (2008-2013)

How often did you buy pearl millet seeds? (Out of six years)

What is your preferred source of seed purchase? (Codes refer 2.8)

What is preferred source of borrowing for seed? (Codes refer 2.8)

2.11 Average Pearl millet yield (grain and fodder) by this household (qtl/acre)

	Rainy season (kharif)		Year	Avg. yield (qtl/acre)	
Year	Grain	Fodder		Grain	Fodder
Normal year			2013-14		
Bad year			2012-13		
Best yield recorded so far			2011-12		

3. Utilization and Marketing

3.1 Pearl millet output utilization in 2013-14

Type of production (Grain & fodder)	Unit (kg/ qtl)	Total Production	Utilization of product					In store
			Saved as seed	Gift/kind payments	Consumed as food	Used as feed	Sold in market	

G: Grain; F: Fodder

3.2 Pearl millet marketing

Grain/ Fodder	Market type (codes A)	Distance (km)	Marketing cost (Rs/qtl)					Qty sold (qtl)	Price (₹/qtl)
			Bagging	Trans-port	Commission agent	Market fee	Hamali (labor)		

Codes A: village market-1, Weekly market-2, Regulated market-3, Others-4

3.3 Give an estimate of Pearl Millet consumption by your family (kg/month)

a) 10 years ago: b) 5 years ago: c) Present:

4. Sources of household income (₹) *(net income from July 2012 to June 2013 only)*

Sources of income	Net income (₹)
1. Income from crops including orchards	
2. Farm work (labor earnings)	
3. Non-farm work (labor earnings)	
4. Livestock (milk and milk products selling)	
5. Income from hiring out bullocks	
6. Income from selling sheep, goat, chicken, meat, eggs, etc.	
7. Rental income (tractor, auto, sprayer, & truck, etc.)	
8. Rent from land, building and machinery, etc.	
9. Income from Caste occupations	
10. Business earnings	
11. Regular salaried jobs (Govt./private)	
12. Out migration	
13. Remittances	
14. Government development Programs (including pensions)	
15. Others	

5. Allocation of resources and crop choices

Plot code	Plot size (acre)	Fertility Rank@	Irrigation access (Y/N)	Crop grown in this plot

@ Rank 1: high, assign in that order

5.1 Quality of land allocated to pearl millet

5.1.1 What were the proportions of different grades of land allocated to pearl millet 10 years ago?

A) Best quality land ---------- (%) B) Medium quality land ---------- (%) C) Poor quality land ---------- (%)

5.1.2 What are the proportions of different grades of land allocated to pearl millet now?

A) Best quality land ---------- (%) B) Medium quality land ---------- (%) C) Poor quality land--------- (%)

5.1.4 Do you agree that pearl millet is now shifted to poor quality land? Yes/No

5.1.3 What other crops can be grown on lands allocated to pearl millet now? What yield you can expect from them?

Crop	Yield expected
1.	
2.	
3.	

6. Fodder use

6.1 What share of your total livestock fodder requirements are met through pearl millet crop ……. (% share)

6.2 What are the other fodder sources to feed your livestock?

6.3 Has reduction in pearl millet area led to reduction in number of livestock?

7. Household consumption expenditure (from July 2012 to June 2013)

Total members of the household consumed the food (adults) ---------- (children <12 years) --------

Item	Code ** D/W/M/Y	Average quantity consumed kg/liter	Average unit price (₹)	Total value (₹)
1. Food expenditure:				
Rice				
Wheat				
Sorghum				
Pearl millet				
Other cereals				
Pigeonpea				
Chickpea				
Green/black gram				
Others pulses				
Milk				
Other milk products				
Cooking oil				
Groundnut kernels				
Non-veg (chicken, mutton, beef, fish, eggs, etc.)				
Fruits				
Vegetables				
Tea, coffee, sugar & gur				
All spices				
Processed food items & hotel expenses				
Other food items				
2. Non-food expenditure:				
Health expenditure				
Education/stationery				
Clothing/shoes				
Entertainment/travel/vehicle				
Ceremonies				
Toddy & alcohol				
Cosmetics (hair oil, soaps, etc)				
Taxes/maintenance				
Pan, beedi, cigarettes, etc.				
Cooking fuel/LPG				
Phone/mobile bill				
Electricity bill (house & farm)				
Others				

** D-day, W- week, M- month, and Y- year

8. Benefits perceived from pearl millet technology at the farm level (*10 years ago and now)*

8.1 Did the improved technologies benefit you in any way? ..... (Y/N)

If no, go to section 8.3

If yes, please provide the following information:

Type of benefit	Pearl millet technologies	
	Benefited (Yes/No)	Extent of benefit (%)
Increased grain yield/acre		
Increased fodder yield/acre		
Overall household welfare position		
Better grain quality		
Better fodder quality		
Reduced duration leading to higher cropping intensity		
Resistance to diseases (Downy mildew)*		
Tolerance to drought*		
Reduction in pearl millet area for meeting family needs due to higher yield (% area reduced)		
Allocation of better land to other crops by growing pearl millet in marginal lands		

* Pl. refer them in terms of yield per acre improved or saved

8.2 Did the adoption of improved technologies lead to change in input-use behavior? --- (Y/N)

If yes, how have you changed the allocation of various inputs to pearl millet cultivation?

Input allocation	When did you change? (year)	Old allocation	Current allocation
Own land allocation (acres)			
Leased-in land allocation (acres)			
Seed rate (kg)			
Mechanization (₹ per acre)			
Fertilizer application cost (kg/acre)			
Pesticide application cost (₹/acre)			
Irrigation expenditure (₹/acre)			
Soil & water conservation expenditure (₹/acre/year)			
Others			

8.3 If the **household has not benefited** by new technology, specify the problems/constraints encountered in adopting them or in realizing the benefits? ***(Three major ones)***

8.4 Perceptions about agricultural sustainability (*Compare the present with that level of 2001-02***)**	
Indicator	Status code*
Livestock population (no. per hh)	
Availability of fodder/grazing pastures	
Area under green manure crops	
Land allocation for food crops (acres)	
Average land holding size of farm (acres)	
Land-use intensity (no. of crops per year)	
Use of legumes in crop-rotations/Inter-cropping	
FYM/other organic matter application rate (Qtl/acre/year)	
Soil and water conservation investments per acre (Private+ Public)	
Soil loss due to erosion	
Soil fertility status (Organic Carbon and NPK levels)	
In-organic fertilizers (N,P,K) application rate (kg/acre)	
Micro-nutrient application(kg/acre)	
Frequency of soil testing and use of fertilizers based on recommendations	
Expenditure on plant protection chemicals (₹/acre)	
Expenditure on farm mechanization (₹/acre)	

* 1- Increased, 2-Constant 3-Decreased

8.5 What are the major trait preferences for pearl millets? (*Three major ones for Grain and Stover)*	
Grain traits	Stover traits
1.	
2.	
3.	

8.6 If you are growing pearl millet in summer, give your experience in brief?

8.7 Suggestions/policies needed for promoting pearl millet crop in future

Investigator name: ---------- Remarks, if any ----------

9. Crop economics module

(To be filled for pearl millet and its competing crop on the same quality of land)

Cost of cultivation module (₹/plot**)** Plot ID no. ----------

Operations		Labor use1			Input/Output		
		Unit	Quantity	Wage rate	Quantity	Unit price	Remarks
1A. Land preparation (Ploughing primary and secondary tillage)	M	D					
	F	D					
	B	D					
	T	HR					
1B. Seedbed preparation	M	D					
	F	D					
	B	D					
	T	HR					
2. FYM/C 2.Compost/Sheep penning/ Tank silt application	M	D					
	F	D					
	B	D					
	T	HR					
FYM/Compost/poultry		QT					
Animal penning		NO					
Date of sowing							
3. Planting/Sowing	M	D					
	F	D					
	B	D					
	T	HR					
4A. Seed: Crop code		KG					
Crop code		KG					
Crop code		KG					
4B. Seed treatment	M	D					
	F	D					
----------		KG					
----------		L					
5A. Fertilizer application	M	D					
	F	D					
----------		KG					
----------		KG					
----------		KG					
----------		KG					
5B. Micronutrient application	M	D					
	F	D					
----------		KG					
----------		KG					

Continued

Operations		Labor use1			Input/Output		
		Unit	Quantity	Wage rate	Quantity	Unit price	Remarks
6. Interculture	M	D					
	F	D					
	B	D					
	T	HR					
7. Weeding/Weedicide application	M	D					
	F	D					
	SP	HR					
Type (sprayer/duster/other)	T	HR					
----------		LT					
----------		LT					
8.Plant protection Spraying /Dusting/ Shaking /Hand picking pest	M	D					
	F	D					
	B	D					
	T	HR					
Type (sprayer/duster/other)	SP	HR					
	DU	KG					

----------							
9. Irrigation	M	D					
	F	D					
	ME	HR					
Source of Irrigation							
10. Watching (Birds, Pigs, etc.)	M	D					
	F	D					
Date of harvesting main crop							
11. Harvesting[2] : Crop code.....	M	D					
Date of Harvesting: Crop2 Crop3	F	D					
Crop code.....	M	D					
	F	D					
Crop code.....	M	D					
	F	D					
12. Threshing and cleaning Crop code.....	M	D					
	F	D					
	B	D					
	TH	HR					
Crop code.....	M	D					
	F	D					

Continued

Operations		Labor use1			Input/Output		
		Unit	Quantity	Wage rate	Quantity	Unit price	Remarks
Crop code.....	B	D					
	TH	HR					
	M	D					
	F	D					
	B	D					
	TH	HR					
13. Marketing (including transport, and storage)	M	D					
	F	D					
	B	D					
	T	HR					
14. Fixed Cost: Land Rent (Ac) Cash		Rs					
Kind		KG					
Land tax (Acre)		Rs					
15. Grain Yield: Crop code.....		KG					
Crop code.....		KG					
Crop code.....		KG					
		KG					
		KG					
16. Fodder yield: Crop code.....		QT					
Crop code.....		QT					
Crop code.....		QT					
		QT					
		QT					
17. Stalk:-------- Crop code.....		QT					
---------- Crop code.....		QT					

Study crop name: ----------Variety: ---------- Plot size: ---------- Season: ----------
Sole/inter-crop: ---------- (if it is intercrop: ratio ----------)

[1] Labor input includes total labor days of family and hired labor for each operation. Specify male and female labor as well as bullock labor separately wherever necessary.
[2] Estimate the labor requirement if you had given to contractor for harvesting.
[3] Specify clearly the units (e.g. 5 kg, FYM - 2 qtl etc).
M = Male labor, F = Female labor, B = Bullock pair labor,
T = Tractor/Truck, TH = Thresher, SP = Sprayer, DU = Duster.
Note: Irrigation (Open dugwell, borewell, Submersible pump, tank, canal, and others (specify) ---------
Note: Cost of hiring tractors\bullocks pair includes cost of operator.
Note: Ask\calculate land rent (₹/acre) for that particular crop.

ICRISAT INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

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We **believe** all **people** have a **right** to **nutritious food** and a **better livelihood.**

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