

## Impacts of Improved Pearl Millet Cultivars in India

U K Deb,<sup>1</sup> M C S Bantilan<sup>2</sup> and K N Rai<sup>2</sup>

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### Introduction

Pearl millet (*Pennisetum glaucum*) is the fourth most important cereal in India in terms of area cultivated after rice, wheat, and sorghum. It provides grain and fodder to milch animals and is usually grown under harsh environments and on poor soils. India grows about 7 Mt of pearl millet grain from 10 Mha of land. The major pearl millet-growing states in India are Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, Haryana, Karnataka, Tamil Nadu, Madhya Pradesh and Andhra Pradesh (Table 1). In terms of yield in 1995-98, Uttar Pradesh stood first, followed by Gujarat, Tamil Nadu, Haryana, Madhya Pradesh, Andhra Pradesh, Maharashtra, Karnataka, and Rajasthan. These nine states covered more than 99% of the total pearl millet area and production in 1995-98. While the area under pearl millet has been declining over time in all the states, except Maharashtra, production has gone up in all the states, except Andhra Pradesh and Tamil Nadu (Table 1). Pearl millet yield increased in all the states and more than doubled in a majority of them in the late 1990s compared to the early 1960s. Increase in yield was associated with increase in area under improved pearl millet cultivars.

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**Deb, U.K., Bantilan, M.C.S. and Rai, K.N.** 2005. Impacts of improved pearl millet cultivars in India. Pages 85-99 in *Impact of Agricultural Research: Post-Green Revolution Evidence from India* (Joshi, P.K., Pal, S., BIRTHAL, P.S., and Bantilan, M.C.S., eds.). New Delhi, India: National Centre for Agricultural Economics and Policy Research and Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

<sup>1</sup> Formerly of the International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, Andhra Pradesh, India.

<sup>2</sup> International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, Andhra Pradesh, India.

**Table 1. Trends in area, production, and yield of pearl millet in India, 1960-98.**

State	1960-65	1970-75	1980-85	1990-95	1995-98
	Area ('000 ha)				
Andhra Pradesh	620	550	490	176	120
Gujarat	1440	1750	1400	1196	1080
Haryana	790	920	820	579	570
Karnataka	500	460	510	361	370
Madhya Pradesh	180	209	176	150	140
Maharashtra	1690	1690	1680	1861	1760
Rajasthan	4470	5080	4810	4754	4550
Tamil Nadu	480	430	340	233	220
Uttar Pradesh	1030	1050	980	806	850
Other states	40	50	45	60	30
India	11240	12189	11251	10176	9690
State	Production ('000 t)				
	1960-65	1970-75	1980-85	1990-95	1995-98
Andhra Pradesh	320	280	320	131	100
Gujarat	640	1220	1400	1106	1280
Haryana	290	560	500	531	580
Karnataka	130	360	200	190	220
Madhya Pradesh	120	137	112	130	130
Maharashtra	480	430	690	1222	1300
Rajasthan	970	1500	1470	2012	1920
Tamil Nadu	300	280	330	275	240
Uttar Pradesh	530	690	790	882	1100
Other states	40	45	48	40	30
India	3820	5502	5860	6519	6900
State	Yield (kg ha <sup>-1</sup> )				
	1960-65	1970-75	1980-85	1990-95	1995-98
Andhra Pradesh	516	509	653	744	833
Gujarat	444	697	1000	925	1185
Haryana	367	609	610	917	1018
Karnataka	260	783	392	526	595
Madhya Pradesh	667	656	636	867	929
Maharashtra	284	254	411	657	739

*Contd.*

**Table 1— Contd.**

Rajasthan	217	295	306	423	422
Tamil Nadu	625	651	971	1180	1091
Uttar Pradesh	515	657	806	1094	1294
Other states	11240	12189	11251	10176	9690
India	340	451	521	641	712

Source: CMIE (2000).

This paper quantifies the extent of adoption and impacts of improved pearl millet cultivars in India.

## Data and Research Methodology

### Data

This study used data from farm-level surveys, crop statistics, and cost of cultivation reports. A reconnaissance survey was conducted to gain preliminary insights into the adoption of production technologies and constraints farmers faced in pearl millet cultivation. This was followed by the collection of secondary data and discussions with officials of the Directorate of Agriculture, scientists from ICRISAT, ICAR, and other research institutes, and representatives from the private seed sector. This was undertaken to provide the basis for an in-depth, on-farm level adoption study. A sampling scheme was designed to select representative pearl millet growers in the top five pearl millet-producing states of India. A total sample of 1683 farmers from 154 villages in 39 districts from Gujarat, Haryana, Maharashtra, Rajasthan, and Tamil Nadu was selected. It may be noted that the survey in Rajasthan was representative of the situation only in eastern Rajasthan (Table 2).

### Analytical Procedure

The study estimated adoption rates of improved pearl millet cultivars and their impact on yield, cost of production, labor employment, and farm income. Information was gathered for each of the cultivars grown by the farmers. Based on their origin, the cultivars were split into six groups — ICRISAT cultivars, NARS public cultivars (IC material), Private (IC material), NARS Public, Private, and Local. ICRISAT cultivars include varieties and hybrids bred by ICRISAT.

**Table 2. Distribution of sample farms in India.**

State	Survey			Sample size
	year	Districts	Blocks	
Maharashtra	1994	9	18	36
Rajasthan	1996	7	14	28
Gujarat	1995	11	21	42
Haryana	1996	5	10	20
Tamil Nadu	1994	7	14	28
Total		39	77	154

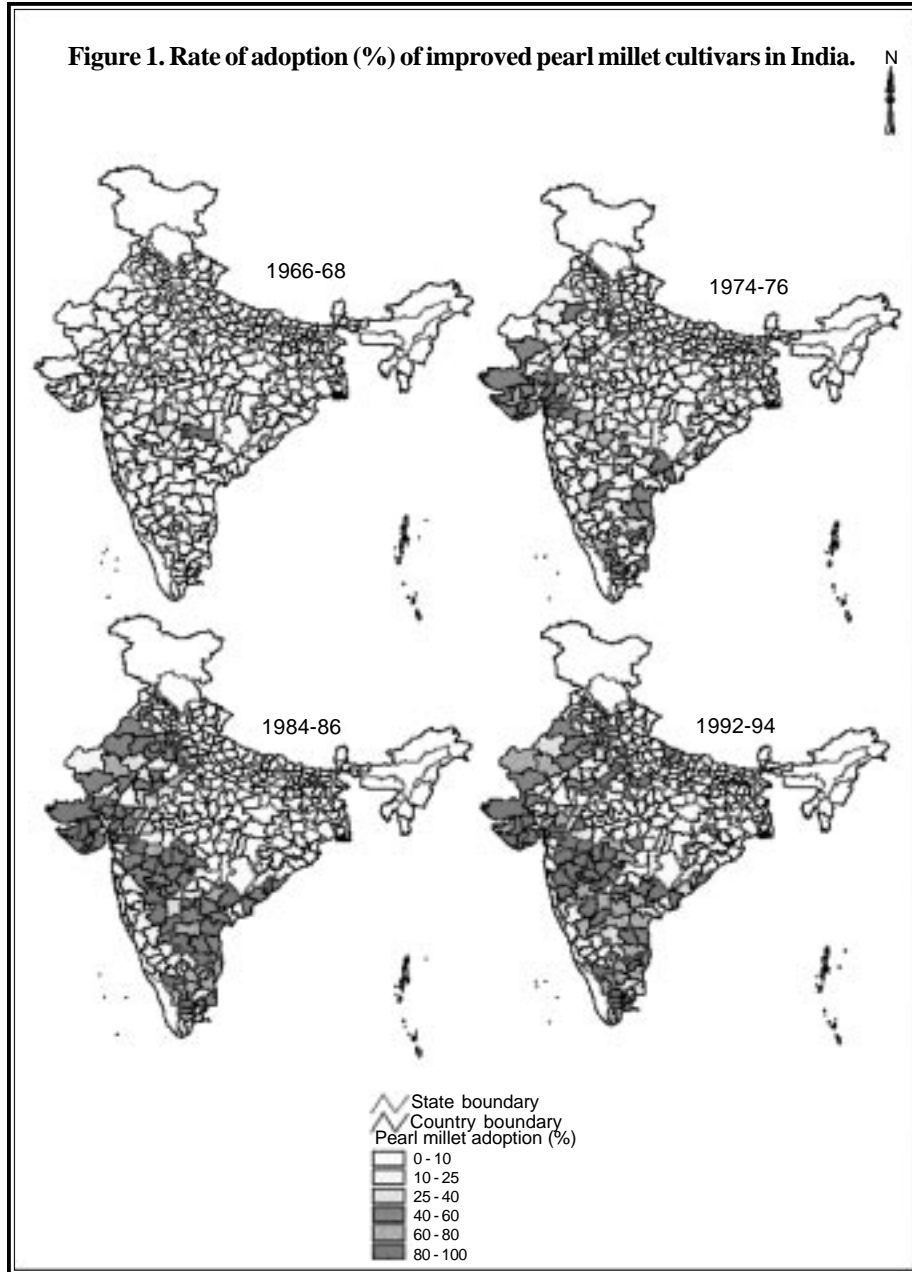
NARS public cultivars (IC material) refer to those varieties and hybrids developed by the Indian Agricultural Research System operated in the public sector but contain germplasm and elite materials collected from ICRISAT in the pedigree. The group of private cultivars (IC material) represents private proprietary hybrid developed from ICRISAT germplasm. On the other hand, NARS public and private cultivars are those developed by the Indian public agricultural research institutes and the private sector respectively, and do not contain any ICRISAT germplasm in their pedigree. Locals are landraces grown by farmers. During the survey, there were occasions when some farmers did not know the name of some of the cultivars but were sure that they were improved ones. Such cultivars were categorized as unidentified improved cultivars.

The adoption level of all improved cultivars was defined as the sum of adoption rates of different improved cultivar groups. Adoption level was defined as the percentage of area under improved pearl millet cultivars to the total pearl millet area.

## Results and Discussion

### Trends in Adoption of Improved Cultivars

Figure 1 shows adoption trends of improved pearl millet cultivars in different districts in India during 1966-94, based on district-level data obtained from published sources. Adoption of improved pearl millet cultivars increased significantly over time, starting from very low adoption levels in the late 1960s. In 1992-94, adoption was over 80% in most districts in Maharashtra, Gujarat,



and Tamil Nadu. About 40 districts in India have attained more than 80% adoption. Increase in adoption over time was influenced by the development of downy mildew-resistant varieties at 4-5-year intervals. Widespread adoption led to major yield gains.

On-farm surveys were conducted to determine the extent of adoption of improved cultivars in farmers' fields in Maharashtra, Gujarat, Haryana, eastern Rajasthan and Tamil Nadu. Table 3 shows the adoption level of different types of improved cultivars adopted by farmers in these states. Adoption was found to be high in Maharashtra, Gujarat, Haryana and Tamil Nadu, while local varieties dominated in Rajasthan. Among the improved cultivars, ICRISAT crosses and public and private sector releases with ICRISAT parentage dominated in Maharashtra and Gujarat. In Haryana, releases by the private and public sectors from ICRISAT materials were grown. However in Tamil Nadu, private releases from non-ICRISAT sources dominated. In eastern Rajasthan, farmers grew public and private sector releases from non-ICRISAT sources.

**Maharashtra.** The area under HYV pearl millet reached 94% in 1994. Adoption of ICRISAT cultivars (ICTP 8203, WC-C75, and MH 179) increased from 35% in 1990 to 47% in 1992, and declined to 36% in 1994. The area under ICTP 8203 increased to 43% in 1992 compared to 29% in 1990 but declined to 30% in 1994. The area under WC-C75 and MH 179 was reported to have declined due to nonavailability of seeds as well as replacement by newer released varieties.

The adoption of NARS-public cultivars (BK 560, BJ 104, MH 169, and RHRBH 8609) declined from 24% in 1990 to 5% in 1994. The area under BK 560 and BJ 104 declined due to their susceptibility to downy mildew. Meanwhile, the area under MH 169 and RHRBH 8609 increased. The average area under NARS-public cultivars during 1990-94 was 19%, of which 4% comprised of hybrids developed using ICRISAT materials.

The adoption of private cultivars (MLBH 104, MLBH 267, etc., from Vijay, Nath, Paras, Mahyco, Pro-agro, Nandi, and Pioneer seed companies) increased from 19% in 1990 to 44% in 1994. The average area under private sector cultivars during 1990-94 was 31%, of which 23% was covered by hybrids developed using ICRISAT materials.

The area under local cultivars declined from 22% in 1990 to 6% in 1994 due to their low yield potential and long duration.

**Table 3. Distribution (%) of pearl millet area under different types of cultivars in India, 1990-96.**

Year	ICRISAT bred	NARS-public (IC material)	Private-(IC material)	NARS-public	Private	Unidentified	Local
<b>Maharashtra</b>							
1990	35.00	0.00	9.00	24.00	10.00	0.00	22.00
1991	44.00	0.00	13.00	21.00	8.00	0.00	14.00
1992	47.00	3.00	22.00	14.00	7.00	0.00	7.00
1993	37.00	9.00	32.00	10.00	8.00	0.00	4.00
1994	36.00	9.00	34.00	5.00	10.00	0.00	6.00
<b>Eastern Rajasthan</b>							
1992	6.75	1.41	1.52	21.40	2.55	10.40	55.97
1993	8.83	1.39	2.50	18.32	3.72	9.82	55.42
1994	11.42	2.53	5.43	19.25	8.93	7.73	44.71
1995	13.09	3.57	5.86	17.56	11.33	4.46	44.13
1996	11.99	2.50	7.14	18.93	12.94	3.52	43.75
<b>Gujarat</b>							
1990	25.76	3.48	6.18	51.39	6.49	0.00	6.68
1991	26.69	5.22	10.24	43.91	10.54	0.00	3.42
1992	29.75	10.52	13.00	33.86	11.13	0.00	1.73
1993	33.70	16.41	19.70	17.81	11.31	0.00	1.07
1994	31.75	21.21	21.41	11.92	12.68	0.00	1.03
1995	31.32	24.81	21.08	7.40	14.40	0.00	1.00
<b>Haryana</b>							
1992	0.63	25.43	13.36	0.00	4.83	0.16	55.60
1993	0.60	32.73	16.38	0.00	6.90	0.60	42.79
1994	1.11	39.76	22.16	0.00	10.42	0.32	26.22
1995	1.68	42.53	24.89	0.00	14.23	0.25	16.43
1996	1.94	42.79	22.90	0.00	18.06	0.25	14.06
<b>Tamil Nadu</b>							
1994	22.6	0	6.6	11.6	36.5	0	22.7

Source: Farm surveys for Maharashtra, Rajasthan, Gujarat, and Haryana, and Ramasamy et al. (1999) for Tamil Nadu.

**Rajasthan.** The uptake of improved pearl millet cultivars in eastern Rajasthan increased from 44% in 1992 to 56% in 1996. BK 560 ranked first among improved cultivars and occupied 20% of the area in 1992 and 18% in 1996. The adoption of another public sector cultivar, HHB 67, increased from 1% in 1992 to 3% in 1995 and then declined to 2% in 1996. MH 179, an ICRISAT-developed cultivar, showed an increase in adoption from 3% in 1992 to 9% in 1996. The adoption of Eknath, a private-sector hybrid based on ICRISAT germplasm materials, increased from less than 1% in 1992 to 4% in 1996. A major shift in adoption occurred in 1994 when many private seed companies introduced their hybrids in the market. The share of local or *desi* pearl millet cultivars among those grown in farmers' field was around 48%.

**Gujarat.** There was a high rate of adoption of improved technologies in Gujarat. Adoption in the rainy season increased from 95% in 1990 to 99% in 1995. During this period, adoption of ICRISAT-developed cultivars (ICTP 8203 and MH 179) increased from 26 to 31% while the adoption of NARS-public cultivars declined from 54 to 32%. In particular, the area under three earlier releases — BK 560, BJ 104, and CJ 104 — declined due to their susceptibility to downy mildew. At the same time, the area under pearl millet cultivars developed by the NARS-public sector based on ICRISAT materials increased from 12% in 1990 to 34% in 1995 and the area under NARS-public cultivars without ICRISAT material fell from 49% in 1990 to 5% in 1995. The uptake of hybrids from the private sector (Nandi 18, Navbharat, Vijay, Prashanth, Deepak, Paras, Mahyco, Pro-agro, and Pioneer) increased from 12 to 35%. It was observed that the area under pearl millet hybrids developed by private seed companies based on ICRISAT germplasm materials increased from 5% in 1990 to 18% in 1995. Notable was the decline in area grown to local cultivars in Gujarat, from 5% in 1990 to less than 1% in 1995, mainly due to their low yields and long duration.

**Haryana.** The adoption of improved pearl millet cultivars increased from 44% in 1992 to 86% in 1996 in Haryana. The percentage of farmers who adopted them increased from 56% in 1992 to 86% in 1996. HHB 67, a public-sector cultivar developed using ICRISAT materials, was widely adopted in the state, covering about 21% of the area in 1992 and increasing to 38% in 1996. It ranked first among the adopted pearl millet hybrids in the state. Nandi 18, an ICRISAT-derived private sector cultivar, ranked second, and its share (cultivated area as a percentage of the total pearl millet area) increased from



9% in 1992 to 17% in 1995 before declining to 16% in 1996. Pro-agro 7701, a private-sector cultivar, stood third in terms of importance in 1996 though it had a much smaller share compared to HHB 67 and Nandi 18 in 1992. Adoption of ICRISAT cultivar MH 179 was about 2% throughout the study period. Cultivars like KH 322, PG 5834, and Nandi 18 showed an increasing trend over the five-year period. Local cultivars declined sharply over the years (from 56% in 1992 to 14% in 1996).

**Tamil Nadu.** NARS private cultivars dominated in Tamil Nadu. The share of ICRISAT cultivars (ICMS 7703, ICMV 221, and WC-C75) was 23%, and they occupied second place. NARS-public cultivars occupied 12% of the area while local varieties were grown over 23% of the area. The rest of the area was under private cultivars. It may be noted that WC-C75 covers about half of the area under ICRISAT cultivars. Among private hybrids, Pioneer dominated two-thirds of the total area under private-sector cultivars. The leading cultivars among NARS public were CO 7 and KM 2 (Ramasamy et al. 1999).

### Traits Preferred and Constraints Faced by Farmers

Farmers were asked to rank the traits they preferred in the improved cultivars they were growing. High grain yield ranked first across the states (Table 4). High fodder yield ranked second in Maharashtra, Haryana, and Gujarat. The other traits farmers liked were short duration, disease resistance, drought resistance, better taste, and bold grain size.

**Table 4. Traits of improved pearl millet cultivars preferred by farmers in select states of India.**

Traits	Ranks provided by farmers of				
	Maharashtra	Rajasthan	Gujarat	Haryana	Tamil Nadu
High grain yield	1	1	1	1	1
High fodder yield	2	4	2	2	
Short duration		2	6	3	
Disease resistance	3	5	3	4	3
Drought resistance	2	3	5	5	2
Better taste	4	7	4		
Bold grain size	5	6			4

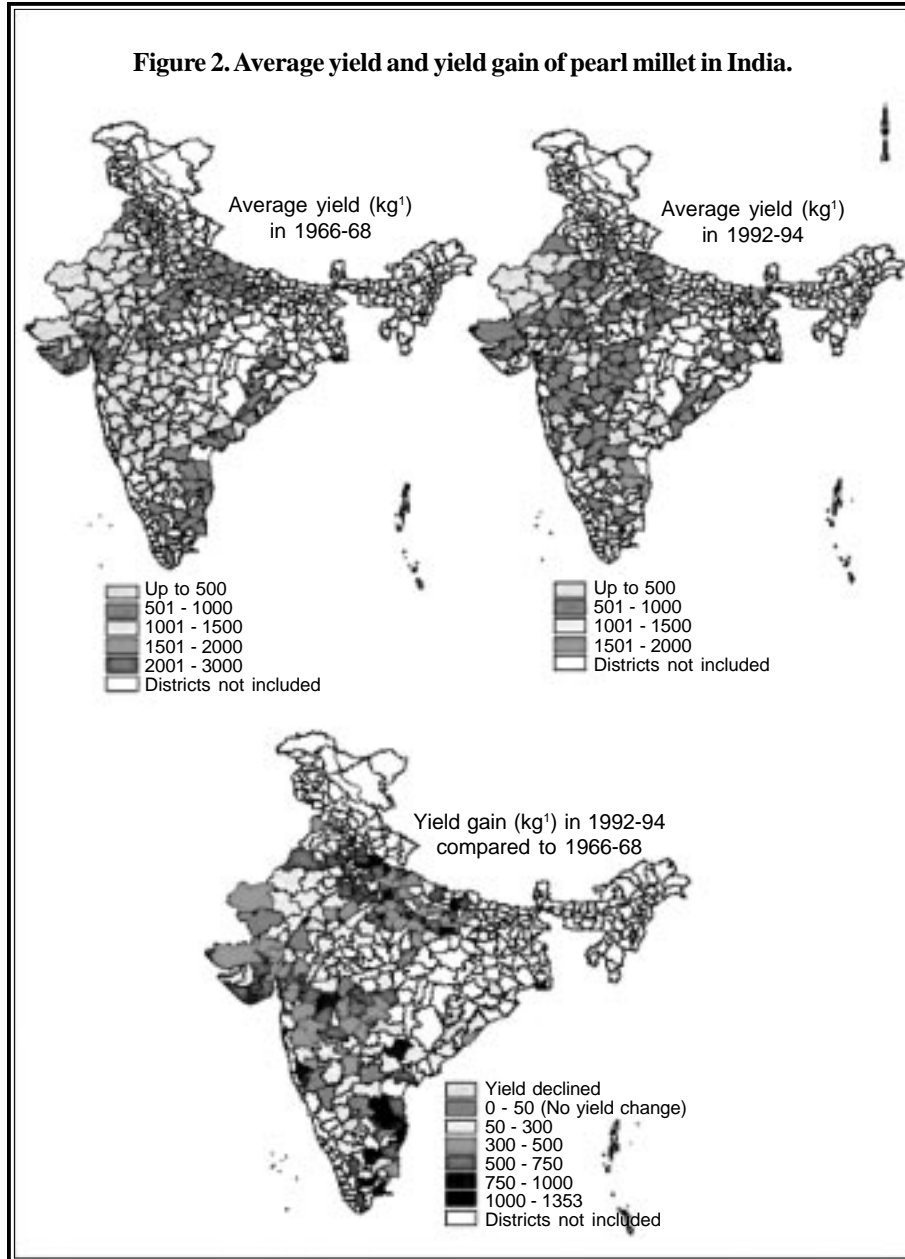
Farmers were also asked to cite and rank the constraints they faced in growing improved pearl millet cultivars. According to them, nonavailability of seed, low fodder yield of existing cultivars, lack of awareness, greater water need, poor extension service, and poor grain and fodder quality were the major constraints (Table 5).

**Table 5. Constraints Indian farmers faced in growing pearl millet cultivars.**

Traits	Ranks provided by farmers of			
	Maharashtra	Rajasthan	Gujarat	Haryana
Nonavailability of seed	1	2		
Low fodder yield		1		
Lack of awareness	2	3		
More water required	4	4		2
Poor extension	3		2	
Poor grain quality		5	1	3
Poor fodder quality	5	1	3	1

### Impacts of Improved Cultivars

The farm surveys (Table 6) revealed that improved cultivars gave higher grain and fodder yields than local varieties in all the states. The percentage increase was higher for grain yield than for fodder yield. Figure 2 shows the average yield and yield gain in pearl millet in India. District-level yield data for 1992-94 and 1966-68 from 238 districts in India were compared in order to estimate the impact on yield. Yield was found to have increased in almost all the districts. For example, in the late 1960s, most districts of Maharashtra and Gujarat recorded yields of less than 500 kg ha<sup>-1</sup> and slightly higher than 500 kg ha<sup>-1</sup> in Tamil Nadu and Haryana. However, in the 1990s, this increased by 500-1000 kg ha<sup>-1</sup> in Gujarat, Maharashtra, and Haryana. Yield increases were particularly substantial in Cuddapah (Andhra Pradesh), and Chengaianna and Salem (Tamil Nadu) where adoption levels were high. Results from cost of cultivation data showed similar yield gains. Compared to 1972-74, yield gain in 1992-94 was 139% in Gujarat, 126% in Haryana, and 110% in Rajasthan (Table 7).



**Table 6. Impact of improved pearl millet cultivars on grain and fodder yields in farm surveys in India.**

Description/state	Yield ha <sup>-1</sup>	
	Grain (kg ha <sup>-1</sup> )	Fodder (kg ha <sup>-1</sup> )
<b>Local variety</b>		
Haryana	587	1600
Rajasthan	355	1800
Maharashtra	929	1800
<b>Improved cultivars</b>		
Haryana	1665	2700
Rajasthan	1170	2000
Gujarat	1955	2500
Maharashtra	1807	1900
<b>Increase in yield (%)</b>		
Haryana	183	7500
Rajasthan	230	1000
Maharashtra	95	600

**Table 7. Impact of improved pearl millet cultivars on pearl millet yield in India, 1972-94.**

State	Average yield (kg ha <sup>-1</sup> )			Yield gain (%) compared to 1972-74	
	1972-74	1981-83	1992-94	1981-83	1992-94
Gujarat	641	1380	1534	115	139
Haryana	578	725	1309	25	126
Rajasthan	265	373	557	41	110

Source: MOA (1996).

Farm survey results showed that improved cultivars had more than 40% lower cost of production estimated on a full cost basis (Table 8). Results from cost of cultivation data revealed that the average cost of pearl millet production per ton in 1992-94 compared to 1972-74 had declined by 35% in Gujarat, 42% in Haryana, and 59% in Rajasthan (Table 9).

**Table 8. Impact of improved pearl millet cultivars on per unit cost of production in India.**

Description/state	Cost of production (Rs t <sup>-1</sup> ) on the basis of		
	Variable cost	Fixed cost	Total cost
<b>Local variety</b>			
Haryana	5308	3022	8329
Rajasthan	5122	4997	10120
Maharashtra	4153	3769	7921
<b>Improved cultivars</b>			
Haryana	3283	1110	4394
Rajasthan	3452	1912	5364
Gujarat	2942	1002	3944
Maharashtra	2429	2047	4476
<b>Reduction in unit cost (%)</b>			
Haryana	38	63	47
Rajasthan	33	62	47
Maharashtra	42	46	43

**Table 9. Impact of improved pearl millet cultivars on unit cost of production<sup>1</sup>, 1971-95.**

State	Average cost (Rs t <sup>-1</sup> )			Cost reduction (%) compared to 1972-74	
	1972-74	1981-83	1992-94	1981-83	1992-94
Gujarat	3814	2665	2464	30	35
Haryana	4277	2881	2488	33	42
Rajasthan	3898	1676	1593	57	59

<sup>1</sup>All costs are real costs of production. Real cost is computed on the basis of 1992 prices.

Source: Estimated from cost of cultivation reports.

In a labor surplus economy like India's, creation of employment opportunities is treated as a benefit of new technology. Table 10 shows that improved cultivars required more labor than local cultivars, thus creating scope for employment. Since employment opportunities were created for both male and female labor, the improved cultivars had a positive gender effect.

**Table 10. Impact of improved pearl millet cultivars on labor employment in India.**

Description/states	Labor use (ha <sup>-1</sup> )		
	Male	Female	Total
<b>Local variety</b>			
Haryana	20	16	36
Rajasthan	16	5	22
Maharashtra	26	45	71
<b>Improved cultivars</b>			
Haryana	29	23	52
Rajasthan	24	12	36
Gujarat	33	33	66
Maharashtra	32	52	89
<b>Increase in labor use (%)</b>			
Haryana	45	41	43
Rajasthan	50	140	64
Maharashtra	23	16	25

Improved cultivars also increased net farm income (Table 11). Local cultivars provided negative income on a full cost basis while improved cultivars provided significant positive income ranging between Rs 1100 and Rs 9700 ha<sup>-1</sup> in different states. Net income computed on the basis of variable cost showed that improved cultivars increased farm income by up to five times.

## Conclusions

The study found that the adoption level of improved pearl millet cultivars has increased to a large extent over the last two and a half decades. Indian farmers largely adopted improved pearl millet cultivars developed by ICRISAT, and public and private sector research institutes from ICRISAT germplasm materials. Pearl millet hybrids developed by the private sector using ICRISAT materials started to dominate the market due to a more effective delivery system and growing investment in research and development. Development of new downy mildew-resistant cultivars, public and private sector efforts in seed multiplication, and timely distribution facilitated the high adoption of improved cultivars in farmers' fields. Qualitative data gathered during on-farm surveys indicate that future research for the development of new pearl millet cultivars