Adoption of Improved Sorghum Cultivars

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8.1. Introduction

Successful development of appropriate improved crop cultivars paves the way for their adoption by farmers. Adoption of improved cultivars is a necessary precondition for plant breeding creating favorable impacts on farm households. Impacts may be obtained through yield increases, quality improvement, reduction in unit cost of production and reduced production risks. This chapter is a compilation of information about the level of adoption of improved sorghum cultivars and factors influencing it.

Adoption of improved sorghum cultivars was measured as a percentage of improved sorghum area in the total sorghum area. Based on their origin, adoption levels of improved sorghum cultivars were divided into four groups: (i) percentage of area sown to ICRISAT-bred cultivars; (ii) percentage of area sown to cultivars having ICRISAT parents; (iii) percentage of area sown to ICRISAT network cultivars; and (iv) percentage of area sown to non-ICRISAT (other) cultivars.

Information on adoption levels of improved sorghum cultivars were obtained from:(i) adoption and impact monitoring surveys carried out by ICRISAT; (ii) a literature survey; (iii) state and district level secondary data for India published in Fertilizer Statistics, State Crop Reports and Statistical Abstracts; and (iv) a rapid appraisal conducted during 1998/99 to estimate cultivar-specific adoption levels in several states of India.

Cultivar-specific adoption data for different sorghum cultivars are not available in published statistics. Cultivar-specific areas and adoption levels have been estimated using Delphi techniques and on the basis of available data on HYV sorghum area for major sorghum-producing states. In India, data on the total area under sorghum crop and HYV sorghum were available in crop statistics published by different states, but data on the area under different cultivars were not available. In order to generate this data, interviews were conducted of specialists working in state seed certification agencies, the National Seed Corporation, state seed development corporations, agricultural research institutes, the directorates of agriculture of major sorghum-producing states, extension personnel of Training and Visit (T&V) offices, private seed companies, seed dealers in different districts of major sorghum-growing states about their perceptions on the popularity of different cultivars in different districts at different points in time. The individuals involved in this process were asked to rank the popular cultivars and mention the likely percentage share of each in the total areas under HYV sorghum. Based on their responses and frank discussions, concrete figures were arrived at for the market share of different sorghum cultivars in the total HYV sorghum area in each region. This information was verified with available data on HYV sorghum area reported in the statistical bulletins published by different states.

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This chapter also discusses technology adoption levels in Asia, Africa and Latin America, the critical factors influencing adoption levels and constraints to adoption of improved cultivars as reported by farmers. Finally, the lessons learned from sorghum cultivar adoption studies conducted in Asia, Africa and Latin America are described.

8.2. Technology Adoption in Asia

Table 8.1 shows the level of adoption of improved sorghum cultivars in several sorghum-producing countries in Asia. China has the highest level of adoption of improved cultivars (98% of sorghum area) in Asia followed by Iran (87%) and India (73%). A description of country-specific adoption follows.

India. The level of adoption of improved sorghum cultivars in major sorghum-producing states of India is shown in Figure 8.1. Significant increases in the level of adoption were observed in all major sorghum-growing states (Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh and Gujarat) except Rajasthan. In 1996/97, the highest level of adoption of improved sorghum cultivars was found in Madhya Pradesh (85% of sorghum area), followed by Maharashtra (84%) and Tamil Nadu (77%). Adoption levels in Andhra Pradesh and Karnataka were about 70% while they reached 52% in Gujarat. On the other hand, the observed adoption level in Rajasthan was only 2%.

Similar analyses were conducted on district-level data from these major sorghum-producing states in India. The level of adoption of improved sorghum cultivars across all districts of India for four periods (1966-68, 1974-76, 1984-86 and 1992-94) are shown in Figure 8.2. The early and rapid levels of adoption in Tamil Nadu, Karnataka and Maharashtra states are evident while a very slow level of adoption was observed in Rajasthan. Levels of adoption were highest (more than 80%) in a majority of sorghum-producing districts of Maharashtra and in some districts of neighboring Andhra Pradesh. In 1992-94, farmers of 28 districts adopted improved cultivars on more than 80% of their sorghum areas. These districts were Nanded, Jalgaon, Nagpur, Yeotmal, Akola, Amravati, Wardha, Kolhapur, Buldhana, Sangli, Nasik, Osmanabad and Dhulia in Maharashtra; Indore, Dhar, Betul and Morena in Madhya Pradesh; Aligarh, Allahabad and Buduan in Uttar Pradesh; East Godavari, Khammam and Karimnagar in Andhra Pradesh; Shimoga and Hassan in Karnataka; Ganganagar in Rajasthan; Tirunelveli Kattabomman in Tamil Nadu; and Rajkot in Gujarat. Another 16 districts had adoption levels ranging between 70 and 80%: Beed, Chandrapur and Parbhani in Maharashtra; Shivpuri, Khargone, Sehore, Raisen, Chindwara, Khandwa, Shajapur and Narsimhapur in Madhya Pradesh; Cuddapah in Andhra

Table 8.1. Adoption level (% area) of improved sorghum cultivars in Asia.

		Percent area sown to				
Country	Year	ICRISAT cross	ICRISAT parent	ICRISAT network	Others	All improved
China	1998	-	9	-	89	98
India	1999	1	10	3	59	73
Iran	1995-96	-	-	-	87	87
Myanmar	1995-96	10	-	-	-	10
Pakistan	1995-96	-	-	-	21	21
Thailand	1995-96	-	10	-	-	10

Source: ICRISAT Impact Monitoring Survey, 1997-2000.

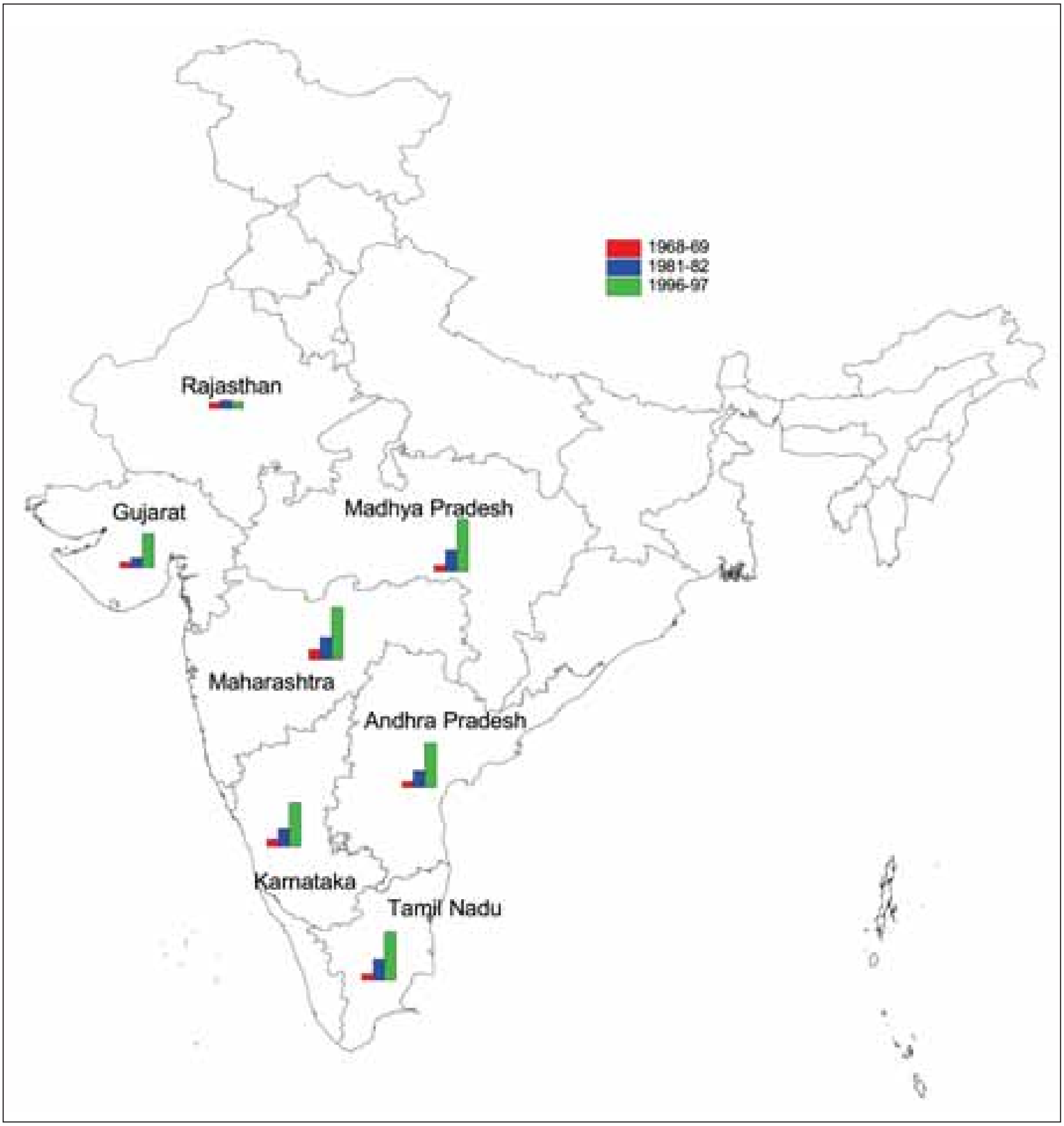


Figure 8.1. Trends in adoption levels (% of total sorghum area) of improved sorghum cultivars in major sorghum-producing states of India, 1968-97.

Pradesh; Chickmagalur and Bellary in Karnataka; North Arcot in Tamil Nadu and Bulandshar in Uttar Pradesh.

The trends in adoption of specific, popular sorghum hybrids in India are shown in Figure 8.3. The slow and limited adoption of CSH 1 is evident, as is the subsequent more rapid and widespread adoption of CSH 5, CSH 6 and CSH 9. The farmers have recently adopted MSH 51, popularly known as Mahyco 51, a cultivar from the private sector. JKSH 22, another cultivar from the private sector, is also gaining its ground. Improved open-pollinated varieties have been less

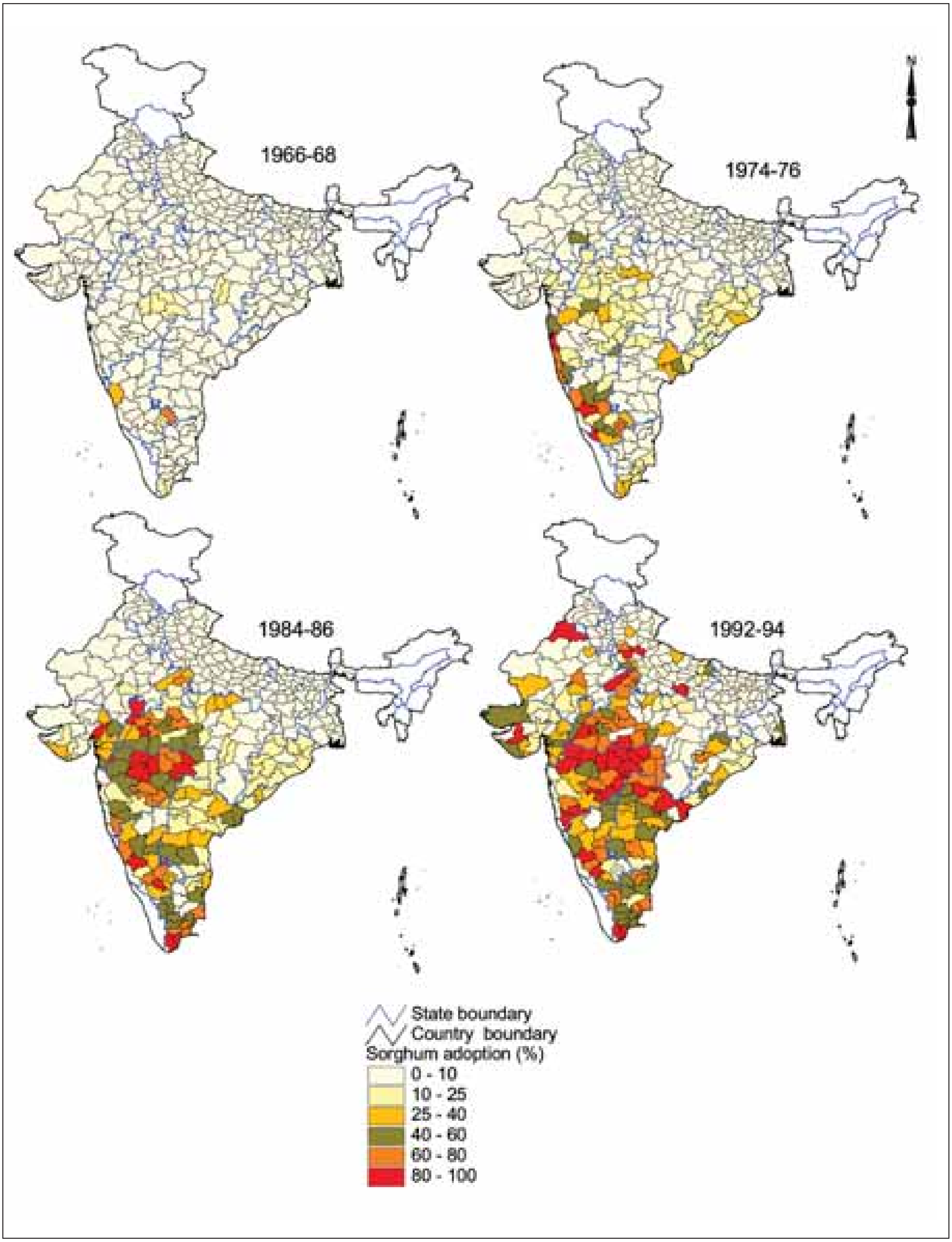


Figure 8.2. Rate of adoption (%) of improved sorghum cultivars in India.

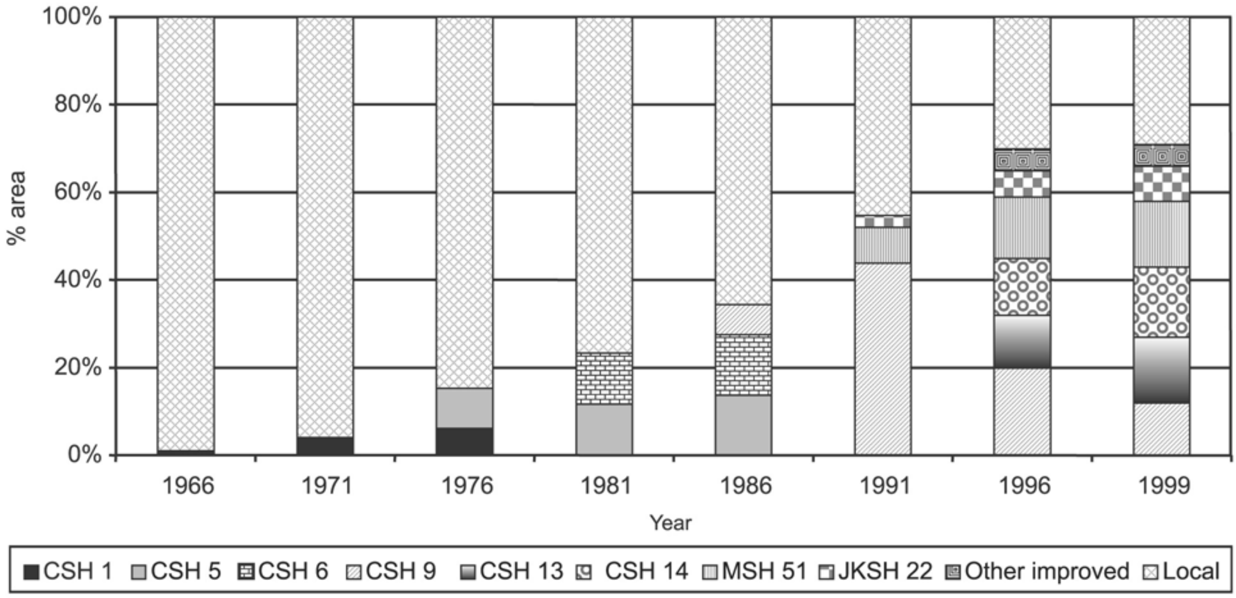


Figure 8.3.Trends in the adoption of different sorghum cultivars in India, 1966-99.

popular than the hybrids from the time these first became available (Rana et al. 1997). Since hybrids provide higher yields and their seed is readily available from a large number of private and public seed companies, adoption of hybrids took off readily. Three phases in the spread of improved sorghum cultivars have been observed in India. The first phase lasted until 1975, when CSH 1 was the only improved cultivar adopted to any extent. During this period, improved sorghum cultivars (CSH 1) mainly replaced traditional local cultivars. The second phase occurred between 1976 and 1986, when the dominant improved sorghum cultivars were CSH 5 and CSH 6. This phase was characterized by the replacement of traditional local cultivars and the initial group of hybrids (CSH 1, CSH 2 and CSH 4) with new hybrids (CSH 5 and CSH 6). The third phase started after 1986, when these second cycle hybrids were replaced by CSH 9, MSH 51, JKSH 22, CSH 13 and CSH 14, which as a group were adopted rapidly and more widely than earlier improved sorghum cultivars. During this period, Indian farmers began to be acquainted with a large number of private-sector bred hybrids in the market. The three phases of adoption are evident in Figure 8.4, which depicts the trends in adoption of improved cultivars in Andhra Pradesh, Gujarat and Maharashtra between 1972 and 1997.

Deb and Bantilan (1998) documented cultivar-specific adoption levels of improved sorghum cultivars in different states of India. A summary of their results (Figs. 8.5a and b) shows that CSH 9 was the most popular cultivar in almost all the major sorghum-growing states in 1993. However, there were regional variations in the popularity of other cultivars. For example, Mahyco 51 was popular in Gujarat, Maharashtra, Madhya Pradesh, Tamil Nadu and Andhra Pradesh. Mahyco had strong distribution and marketing networks in these states.

China. The levels of adoption of improved sorghum cultivars in China are the highest among all Asian countries. A series of generations of new cultivars consistently replaced old cultivars over time (Table 8.2). In 1994, 99% of the total sorghum area in China was sown to improved cultivars. Hybrids are more popular than varieties. Even in 1975-76, the level of adoption of improved sorghum cultivars in China was 90%. The popularity of different hybrids in China varied over time.

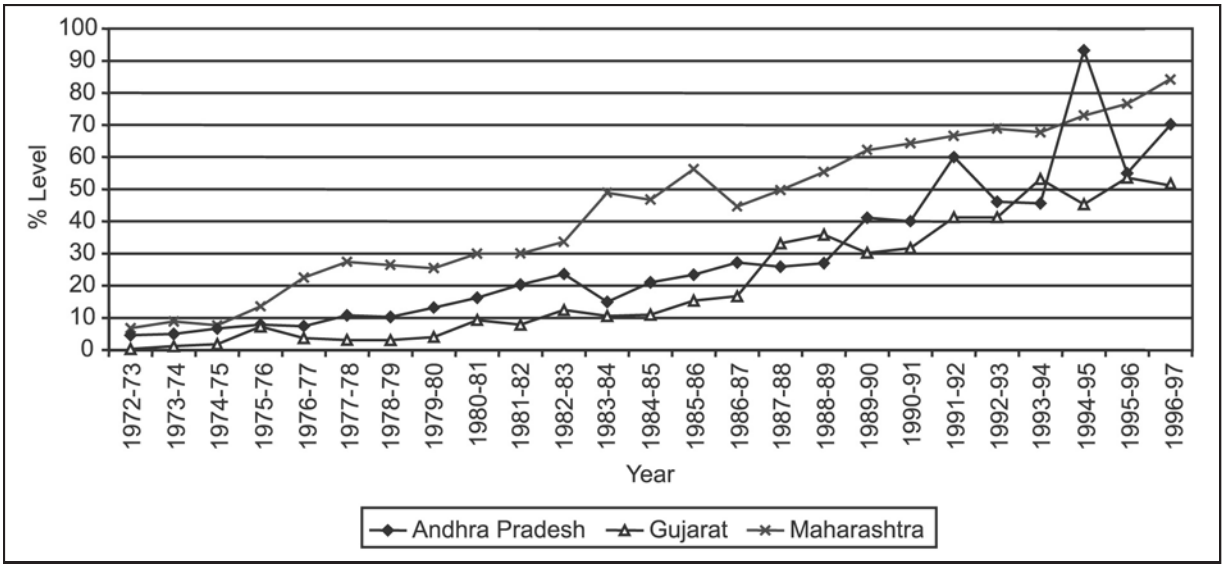


Figure 8.4. Trends in the adoption level (%) of improved sorghum cultivars in selected states of India, 1972-97.

In 1975-76, six sorghum hybrids (Jin Za No. 1, Xin Za No. 52, Jin Za No. 4, Jin Za No. 5, Ji Za No. 11 and Ji Za No. 26) occupied more than 60% of the total sorghum area. Jin Za No. 5 covered about 19% of the sorghum area in China in 1975-76. In 1980-81, the two most popular cultivars were Liao Za No. 1 and Zin Za No. 83 which covered 22% of the total sorghum area. Four other cultivars (Liao Za No. 2, Shen Za No.4, Tie Za No. 6 and Tie Za No. 7) covered about 11% of the total area. Only 5% of the total sorghum area in China was under local cultivars in 1980-81. In 1985-86, only 2% of the total sorghum area was under local cultivars. Popular cultivars were Shen Za No. 5, Qiao Za No. 2, Liao Za No. 4 and Jin Za No. 94, which together covered about 20% of the total sorghum area in China. In 1990-91, the level of adoption of improved cultivars was 98% and four cultivars (Long Si Za No. 1, Jin Za No. 12, Tie Za No. 10 and Liao Za No. 5) were the most popular. By 1994, 99% of the total sorghum area of China was under improved cultivars. Four improved cultivars (Long Za No. 3, Liao Za No. 6, Liao Za No. 7 and Liao Za No. 10) were the most popular. In 1999, 9% of sorghum area in China was sown to cultivars having ICRISAT parents. As shown in Table 8.2, the popularity of new generations of improved sorghum cultivars, speedy turnover of new cultivars and dominance of hybrids over OPVs were the features of adoption of improved sorghum cultivars in China during this 20-year period.

Myanmar. Adoption levels of improved sorghum varieties were low in Myanmar. In 1975-76, only local sorghums were in cultivation while in the mid 90s, all area under improved cultivars (9.73%) was sown to ICRISAT-bred varieties (Table 8.3). In 1980-81, the level of adoption of improved cultivars was 28% and the popular cultivars were (Shwe Ni 1, Shwe Ni 2, Shwe Ni 3, Shwe Ni 4, Shwe Ni 5, and Shwe Ni 9). The level of adoption fell to only 9% in 1985-86 and the popular cultivars at that time were Shwe Ni 1, Yezin White Grain 1 and Yezin White Grain 2. By 1990-91, the level of adoption fell further to 6% and the popular improved cultivars were Shwe Ni 1, Shwe Ni 4, Yezin White Grain 1, Yezin White Grain 2 and Yezin White Grain 3. The fluctuation in adoption has been influenced by the weakening public sector seed multiplication, distribution and extension programs compared to two decades ago. By the mid-90s, the adoption level of improved cultivars had returned to 9.73% and the most popular cultivars were Yezin White Grain 1, Yezin White Grain 2 and Yezin White Grain 3.

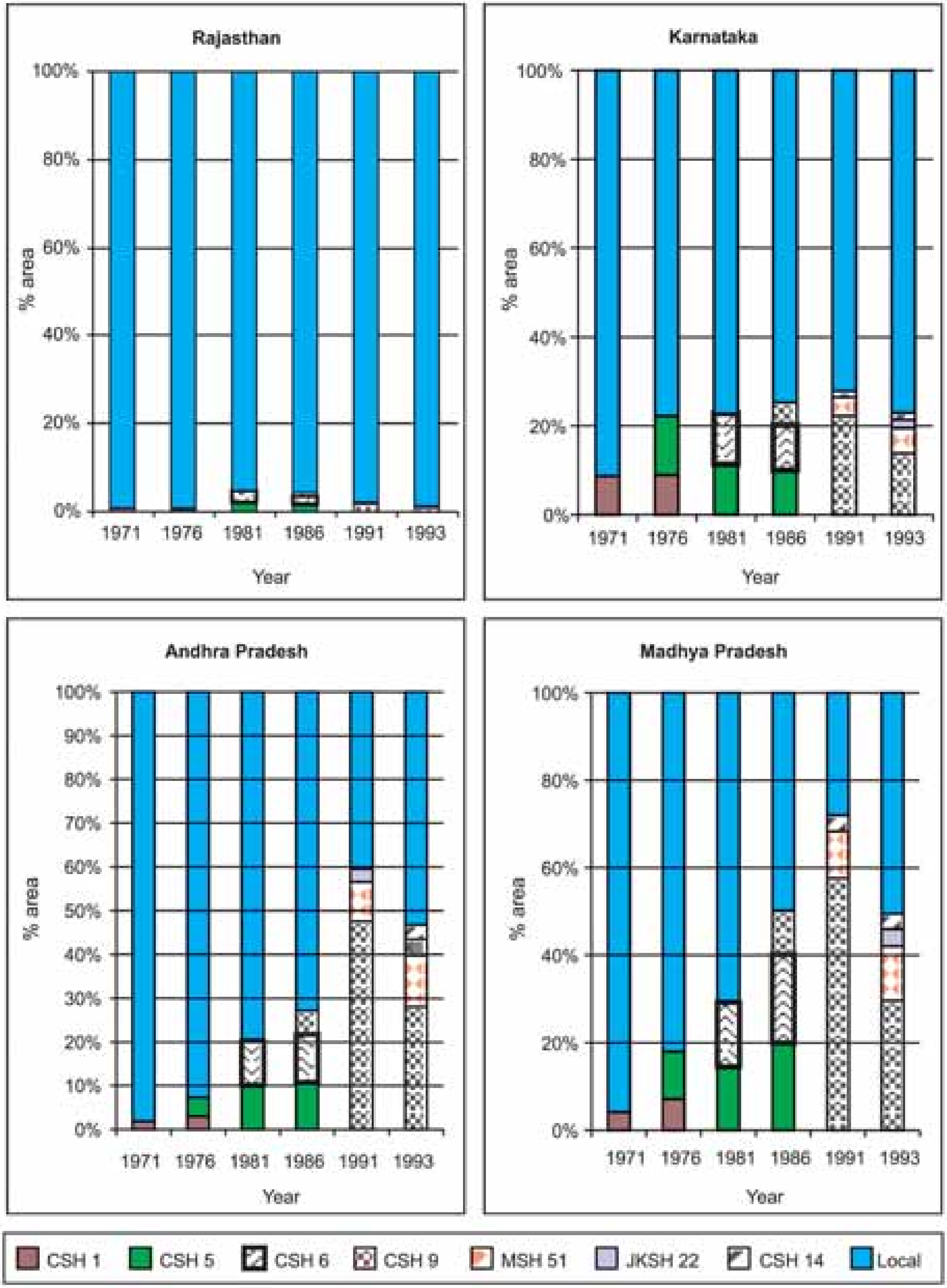
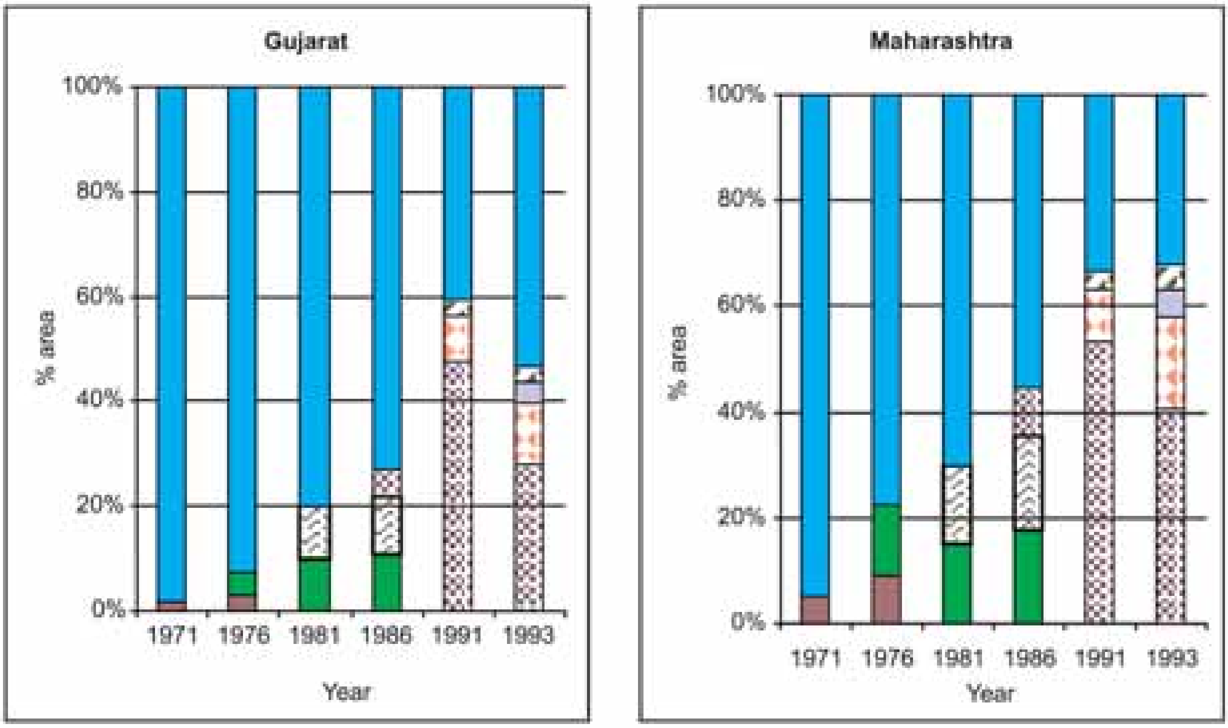
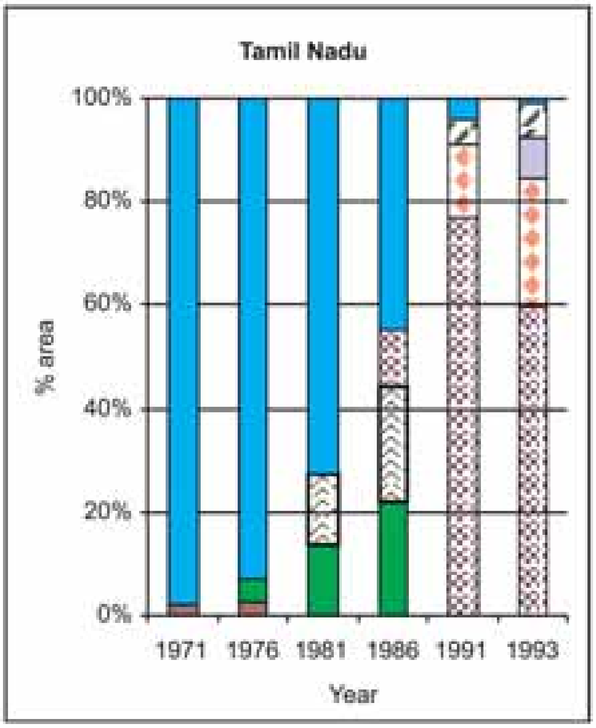


Figure 8.5a. Trends in the adoption rate of different sorghum cultivars in selected states of India, 1971-1993.





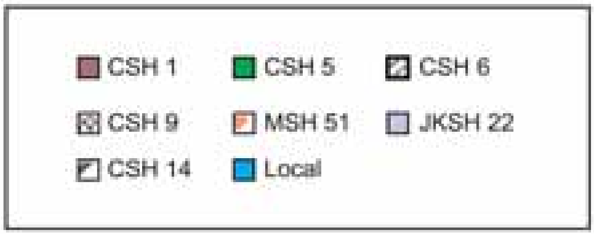


Figure 8.5b. Trends in the adoption rate of different sorghum cultivars in selected states of India, 1971-1993.

Pakistan. Local cultivars have always dominated sorghum cultivation in Pakistan. In the mid-70s, only 7% of the total sorghum area in Pakistan was sown to improved cultivars, but this increased to 21% by the mid-90s (Table 8.4). However, as of 1995-96, no ICRISAT cultivars were grown in Pakistan.

Table 8.2 . Trends in the adoption level (%) of improved sorghum cultivars in China, 1976-94.

Cultivar	1976	1981	1986	1991	1994
Jin Za No. 1 (hybrid)	6.22				
Xin Za No. 52 (hybrid)	6.38				
Jin Za No. 4 (hybrid)	12.42				
Jin Za No. 5 (hybrid)	18.90				
Ji Za No. 11 (hybrid)	7.94				
Ji Za No. 26 (hybrid)	8.38				
Tie Za No. 6 (hybrid)		2.34			
Liao Za No. 1 (hybrid)		10.50			
Liao Za No. 2 (hybrid)		2.34			
Jin Za No. 83 (hybrid)		10.59			
Shen Za No. 4(hybrid)		3.51			
Tie Za No. 7 (hybrid)		2.34			
Shen Za No. 5 (hybrid)			6.72		
Qiao Za No. 2 (hybrid)			4.48		
Liao Za No. 4 (hybrid)			4.48		
Jin Za No. 94 (hybrid)			4.47		
Jin Za No. 12 (hybrid)				8.86	
Tie Za No. 10 (hybrid)				5.18	
Liao Za No. 5 (hybrid)				6.21	
Long Si Za No. 1 (hybrid)				3.13	
Long Za No. 3 (hybrid)					7.29
Liao Za No. 6 (hybrid)					4.28
Liao Za No. 7 (hybrid)					2.45
Liao Za No. 10 (hybrid)					1.64
Other improved	29.74	63.39	77.86	74.61	83.35
Local	10.00	5.00	2.00	2.00	1.00
All	100.00	100.00	100.00	100.00	100.00
Total sorghum area	4333.50	2613.10	1898.69	1414.10	1392.97

Source: ICRISAT Impact Monitoring Survey (1997). Total sorghum area-units (‘000 ha) (FAOSTAT 2003).

Table 8.3. Trends in the adoption level (%) of improved sorghum cultivars in Myanmar, 1981-94.

Varieties	1981	1986	1991	1994
Shwe Ni 1	10.41	2.40	1.31	
Shwe Ni 2	1.37			
Shwe Ni 3	1.83			
Shwe Ni 4	1.26		0.65	
Shwe Ni 5	4.46			
Shwe Ni 9	8.41			
Yezin White Grain 1		1.60	2.97	3.89
Yezin White Grain 2		5.29	1.07	1.95
Yezin White Grain 3			0.30	3.89
Local	72.25	90.72	93.70	87.73
Total	100.00	100.00	100.00	97.46

Source: ICRISAT Impact Monitoring Survey (1997).

Table 8.4. Trends in the adoption level (%) of improved sorghum cultivars in Pakistan, 1976-94.

Cultivars	1976	1981	1986	1991	1994
All improved	7	8	13	16	21
Local	93	92	87	84	79
Total	100	100	100	100	100
Total sorghum area ('000 ha)	446.94	392.50	399.20	382.70	438.20

Source: ICRISAT Impact Monitoring Survey (1997); FAOSTAT (2003).

Thailand. In Thailand, improved cultivars having at least one ICRISAT parent covered 10% of the country's total sorghum area in 1995-96. Thailand has released seven improved cultivars. Two varieties (Early Hegari and Late Hegari) were introduced in the early 1960s from USA. Hegari is still popular in Thailand. The other five improved cultivars are materials developed by the national breeding program. One of the cultivars (Suphan Buri 1, released in 1993) had ICRISAT-supplied germplasm as a parent.

Iran. All sorghum grown in Iran up to 1985-86 were local varieties. However, by 1995-96, 87% of the sorghum growing area in Iran was under improved cultivars. None of this area was sown to ICRISAT cultivars. It may be noted that the total area under sorghum in Iran is low, but it has been increasing over time, from 4 000 ha in 1980-81 to 30 000 ha in 1995-96.

8.3. Technology Adoption in Africa

Table 8.5 shows the levels of adoption of improved sorghum cultivars in African countries. South Africa had the highest adoption level (77%) in Africa followed by Swaziland (50%), Zimbabwe (36%) and Zambia (35%). Country-specific adoption situations are discussed below.

Southern and Eastern Africa. Phofu is the most popular improved variety in Botswana. Its adoption level in 1997/98 was 21% (Rohrbach et al. 1999). Levels of adoption of ICRISAT-bred varieties in Sudan, Malawi, Zambia and Zimbabwe in 1997 were 3%, 10%, 35% and 36%, respectively (Table 8.5). The level of adoption of improved sorghum cultivars in South Africa in 1997 was 77% but all were non-ICRISAT cultivars. It may be mentioned here that South Africa began receiving ICRISAT sorghum materials only in 1994/95, due to which ICRISAT cultivars have not yet been released in that country.

Egypt. Most of the sorghum area in Egypt is sown to local varieties. In 1975-76, only 5% of Egypt's sorghum area was under improved cultivars. However, this increased to 35% (including 15% of the area under OPV selections from ICRISAT crosses and hybrids having ICRISAT parents) in 1993-94 (Table 8.6). In 1975-76, Giza 114 was the only improved cultivar grown in Egypt; it covered 5% of the sorghum area.In 1980-81 two cultivars—Giza 114 (4.4%) and Giza 15 (10.6%)—covered 15% of the country's total sorghum area. By 1985-86, Giza 114 was out of cultivation in Egypt and Giza 15 became the most popular cultivar covering 15% of the total sorghum area. Two other improved cultivars, ISIAP Dorado and NES 1007, were also grown at that time and jointly covered about 5% of Egypt's sorghum area. By 1990-91, Giza 15 covered about 20% of the total sorghum area while ISIAP Dorado, NES 1007 and Giza 113 had a share of 8%, 1% and 1%, respectively. Giza 15 is still popular in Egypt and covered about 17% of the sorghum area in 1993-94. The other

Table 8.5. Level of adoption (% area) of different improved sorghum cultivars in Africa.

			Percent area planted to				
Country	Region	Year	ICRISAT cross	ICRISAT parent	ICRISAT network	Others	All improved
Angola	National	1997					17
Botswana	National	1997/98	33				33
Cameroon	Mayo Sava	1995	49				
	Diamare	1995	14				
	Mayo Danay	1995	12				
Chad	Guera, Mayo Kebbi, Chari Baguirmi	1995	27				27
	Guera	1995	38				
	Mayo Kebbi	1995	27				
	Chari Baguirmi	1995	24				
Egypt		1995/96		5		30	35
Lesotho		1997	4				4
Malawi			10				10
Mali		1995	29				29
Mozambique			5				5
Nigeria	Kano	1996/97	28				28
	Katsina		10				10
	Kaduna		29				29
	Jigawa		3				3
South Africa		1997					77
Sudan		1995/96	3			19	22
Swaziland		1997					50
Tanzania		1997					2
Zambia			35				35
Zimbabwe			36				36

Source: ICRISAT Impact Monitoring Survey, 1997-2000; Ogungbile et al. (1998) for Nigeria; Rohrbach and Makhwaje (1999) for Botswana; SMIP (1999) for Angola, Lesotho, South Africa, Swaziland and Tanzania; Yapi et al. (1998) for Mali; and Yapi et al. (1999) for Cameroon and Chad.

Table 8.6. Trends in the adoption level (%) of improved sorghum cultivars in Egypt, 1976-94.

Cultivars	1976	1981	1986	1991	1994
Giza 114	4.82	4.39			
Giza 15		10.53	15.00	19.92	17.00
ISIAP Dorado			2.02	7.99	10.00
NES 1007			2.98	0.96	
Giza 113				0.96	3.00
Hybrids					5.00
Locals	95.18	85.00	80.00	70.01	65.00
Total	100.00	100.00	100.00	100.00	100.00
Total sorghum area ('000 ha)	199.39	173.38	155.68	136.02	158.03

Source: ICRISAT Impact Monitoring Survey, 1997-2000 for cultivar-specific adoption level; FAOSTAT (2003) for the sorghum area in Egypt.

popular improved cultivars were Giza 113 and ISIAP Dorado. The case of ISIAP Dorado is particularly interesting as this short-statured, large- and hard-grained, high-yielding, white-grained/ tan plant OPV was selected from breeders' nurseries at ICRISAT-Patancheru by an in-service trainee from El Salvador in 1979/80. Following its release in El Salvador (as ISIAP Dorado), it has been widely used and distributed by both ICRISAT and INTSORMIL. It is now cultivated in El Salvador, Mexico, Honduras, Panama and Paraguay, in addition to Egypt.

Nigeria. Local sorghum varieties are still dominant in Nigeria. Two ICRISAT-bred cultivars (ICSV 111 and ICSV 400) are gaining popularity among farmers of Nigeria. Ogungbile et al. (1997) conducted a study in 1996 to determine the nature, extent and determinants of adoption of ICSV 111 and ICSV 400. A survey was conducted in 27 villages (9 in Kano, 9 in Katsina, 6 in Kaduna and 3 in Jigawa). A total of 219 farmers from these four states were interviewed. Levels of adoption of improved cultivars (ICSV 111 and ICSV 400) were 28% in Kano, 10% in Katsina, 29% in Kaduna and 3% in Jigawa.

Chad. Yapi et al. (1999) studied the adoption and benefits of ICRISAT-bred improved sorghum variety S 35 in Chad, based on farm survey data collected from 152 farmers in 17 districts in 28 villages for 1994/95. This study was conducted in three zones, Guéra, Mayo Kebbi and Chari Baguirmi, which are located in the Sahelian and the Sahelian-Sudanian zones, where short rainy seasons with erratic rainfall patterns necessitate the use of short-cycle crop varieties such as S 35. These zones were the target and distribution zones for S 35 in Chad. The adoption level for S 35 was higher in Guéra (38%) than in Mayo Kebbi (27%) and Chari Baguirmi (24%). This is because Guéra is the zone most suited to S 35 cultivation, and most of the S 35 seed produced at Gassi Research Station between 1987 and 1989 was distributed in this zone. In Chari Baguirmi, adoption only began in 1992 and reached 24% in 1995. This lower adoption level can be explained by farmers' preference for local red sorghum (*djigari*) compared to white sorghums such as S 35; the favorable climate for cultivation of other crops and the nonavailability of S 35 seed.

Cameroon. Ndjomaha et al. (1998) studied the adoption and impact of improved sorghum variety S 35 in northern Cameroon. S 35 was bred at ICRISAT-Patancheru (India) and introduced to this area in 1986. This area is popularly called the cotton belt of north-central Cameroon and is divided into three zones: Mayo Sava, Mayo Danay and Diamaré. Thirty-four villages were selected (8 in Mayo Sava, 14 in Diamaré and 12 in Mayo Danay) and a total of 571 farmers (136 from Mayo Sava, 250 from Diamaré and 185 from Mayo Danay) were interviewed. Ten years after its introduction, S 35 was being grown on 50% of the rainfed sorghum area by 85% of the farmers in the Mayo Sava zone, but was much less popular in the Diamaré (14% area) and Mayo Danay (12% area) zones.

Kamuanga and Fobasso (1994) conducted a similar study of S 35 adoption in north-central Cameroon in 1990. The study found that 13% of farmers adopted S 35, with 8.7% of the area covered by rainfed sorghum.

Mali. Yapi et al. (1998) studied the adoption of improved sorghum cultivars in three regions – Koulikoro, Ségou and Mopti – of Mali. The study locations were at elevations between 400 and 900 m, but each occupied a different ecological niche. Data were collected from 300 units of agricultural production (UAP) spread over 43 villages in Mopti, Ségou and Koulikoro in 1995 following a three-stage sampling procedure.

There were 213 adopters from 300 UAPs, with adoption levels in terms of cultivated area ranging from 17 to 29% between 1990 and 1995 across all three regions. During this period, adoption levels rose from 20 to 30% in Koulikoro, 14 to 29% in Ségou and 14 to 23% in Mopti. The marginally higher levels in Koulikoro can be explained by the importance of sorghum in the local diet and favorable conditions for sorghum cultivation. Adoption levels in the other two regions are relatively high considering that sorghum is a secondary crop in local diets there.

8.4. Technology Adoption in Latin America

CGIAR (1996) reported that more than a fifth of the sorghum area in 1993 in four Central American countries was sown to improved cultivars bred or introduced to the region through the ICRISAT program (often in collaboration with those of INTSORMIL and NARS). This included almost half the sorghum area in Guatemala, a third in Honduras and a fifth in Nicaragua and El Salvador (Table 8.7).

Table 8.7. Level of adoption (% of sorghum area) of improved sorghum cultivars in Central America.

		Percent area planted to	
Country	Year	Cultivars released through ICRISAT program	Others
Central American countries	1993	>20	NA
Guatemala	1993	49	NA
Honduras	1993	33	NA
Nicaragua	1993	20	NA
El Salvador	1993	20	NA
Honduras (southern region)	1990	-	15

Source: López-Pereira et al. (1994) for Honduras; and CGIAR (1996) for other countries.

López-Pereira et al. (1994) and López-Pereira and Sanders (1992) reported that approximately 15% of the sorghum area in Honduras was covered by two improved sorghum cultivars (the hybrid Catracho and the variety Sureño) developed by the Ministry of Natural Resources' National Sorghum Program and INTSORMIL. These cultivars were adopted in the southern region of Honduras, which produces approximately 56% of the nation's sorghum. These high-yielding cultivars have good tortilla quality and respond well to chemical fertilizers, especially under improved soil and moisture conditions (Clara 2000).

8.5. Critical Factors Influencing Adoption

Surveys conducted in Nigeria, Chad, Cameroon and Mali collected information on reasons for the adoption of improved sorghum cultivars and the constraints to adoption faced by farmers (Table 8.8). Ogungbile et al. (1998) mentioned farmers' reasons for growing and not growing improved sorghum varieties (ICSV 111 and ICSV 400) in Nigeria. Early maturity topped the list of reasons for growing these new varieties while high yield ranked second. Good food quality, ease of threshing and processing ranked third, fourth and fifth, respectively.

Farmers of Chad had a number of reasons for adopting S 35. The three most common were early maturity, high yield and good taste (Yapi et al. 1999). Early maturity is more important to farmers in Guéra than in the other two regions because end-of-season drought stress is a serious problem in that region. Early maturity is equally important in Mayo Kebbi (73%) and Chari Baguirmi (75%). Contrary to common belief, however, early maturity is not always associated with drought tolerance — it does provide a mechanism to escape more readily predictable end-of-season drought stress but can actually increase vulnerability to mid-season drought stress. The percentage of farmers citing high yield as an important factor in all three study zones confirms the importance of this criterion independent of agroclimatic zones. Good taste was an important trait for adoption in Guéra because dietary habits in this region favor white sorghum; in fact, there is a price difference between the two types of sorghums in Chad, especially in Guéra. It is surprising that such a high percentage of farmers (53% in Mayo Kebbi and 38% in Chari Baguirmi) adopted S 35 for its taste, especially in Chari Baguirmi where red sorghum is preferred. Less commonly cited reasons for adoption by the farmers included drought tolerance, a higher selling price and the 'sweetness' of the sorghum stalk.

Higher grain yield and tolerance to late sowing of S 35 and extension services from PNVFA (Program national de vulgarisation et de formation agricoles) were key factors influencing adoption of S 35 in Cameroon. Mayo Sava benefited from PNVFA services since 1989, while Diamaré and Mayo Danay were covered only in 1992 and 1994. These extension efforts certainly have contributed to the higher adoption level of S 35 in Mayo Sava. Over the 10-year period (1986-95), S 35's yield advantage over the local variety was 432 kg in Mayo Sava, 89 kg in Diamaré and 52 kg in Mayo Danay. These differences indicate a better genetic potential for S 35 in Mayo Sava than in the other two areas, probably because rainfall there is more congruent with the 300-800 mm research target regime. During the same period, average rainfall in Mayo Sava was 687 mm, while Diamaré and Mayo Danay received 819 mm and 811 mm rainfall, respectively. Local sorghum varieties are usually

Table 8.8. Factors influencing adoption of improved sorghum cultivars in African countries.

Country	Region	Year	Cultivar	Factors influencing adoption
Botswana	National	1997	SDS 3320 (Phofu)	Broad acceptability of the variety for early maturity, large head and large white grain and strong stem resistant to lodging.
Cameroon	Mayo Sava, Diamaré, Mayo Danay	1995	S 35	Yield gain (600 kg ha^{-1}) maximum during drought years when landrace yields are almost nil. Widely adopted for early maturity.
Chad	Guéra, Mayo Kebbi, Chari Baguirmi	1995	S 35	Widely adopted for early maturity and fodder/food quality.
Malawi	National		SPV 351	Widely accepted for early maturity.
Mali	Ségou, Koulikoro, Mopti	1995	All improved	Reasons for adoption of new sorghum varieties for all the three regions of Mali were earliness (85% farmers cited this), productivity (67%) and food quality (34%). These reasons varied in order and in importance in the three regions, perhaps due to rainfall differences.
Mozambique			ICSV 88060	Drought relief program distribution.
Nigeria	Kano, Katsina, Kaduna, Jigawa	1996-97	ICSV 111, ICSV 400	High yield and early maturity are the major reasons for adoption. Farmers cited good food quality, ease of threshing and processing, insect and disease resistance and lower labor requirement as reasons for adoption.

Source: Rohrbach and Makhwaje (1999) for Botswana; Yapi et al. (1999) for Cameroon and Chad; Yapi et al. (1998) for Mali and Ogungbile et al. (1998) for Nigeria.

sown in June, but S 35 can be sown up to 15 July. Thus, when June rainfall is weak, S 35 fares better. Farmers of Cameroon cited several reasons for adopting S 35 – earliness, and food and feed quality. In addition, farmers in Mayo Sava and Diamaré appreciate S 35 for its high productivity and grain color. In Mayo Sava, 27% of those interviewed adopted the variety for its high market price, which was 22-40% higher than the local variety. In Diamaré, the stem of S 35 is consumed like sugarcane, a characteristic that was mentioned by nearly 20% of the farmers (Ndjomaha et al. 1998).

Kamuanga and Fobasso (1994) conducted a similar study of S 35 adoption in north-central Cameroon in 1990. Reasons for adoption cited by farmers were similar in the two studies. The study determined that adopters of S 35 cultivate relatively large areas, and have more plows and draft animals than the non-adopters. They also have more contact with extension agents and seem to exploit new technologies more readily. Factors such as education and age do not seem to affect adoption, but most of the adopters belong to the Mafa, Toupouri and Guiziga groups. On the other hand, the Foulbé, Moundang and Masa cultivate smaller amounts of S 35. This can be explained by the wide availability of the local red-grained variety Djagari, which is a good substitute for S 35 in the zones where the non-adopters live.

Yapi et al. (1998) mentioned that the main reasons for adoption of new sorghum varieties for all the three regions of Mali were earliness (85%), productivity (67%) and food quality (34%). These reasons varied in order and in importance in the three regions, perhaps due to rainfall differences.

8.6. Constraints to Adoption as Reported by Farmers

Low soil fertility was a constraint to adoption of improved sorghum cultivars generally mentioned by all Nigerian farmers. Farmers felt that the improved cultivars (ICSV 111 and ICSV 400) would not do well on marginal land without adequate fertilizer application. Another important constraint mentioned was insect damage. The improved varieties were reported to be susceptible to stem-borer attack. This was attributed to the sugary nature of the stem. Another problem was 'die-back' which prevents good crop establishment. While people in Katsina and Jigawa who produce at subsistence level were concerned about the taste and texture of food prepared from grain of improved cultivars, farmers in Kaduna and Kano who produce grain for sale were not concerned about organoleptic characteristics of the grain (Ogungbile et al. 1998).

Lack of seeds was the major reason mentioned by most of the respondents in the Nigerian study for not growing the improved varieties. It was noted that breeders and other researchers had provided seeds as part of on-farm trials but it was not possible for everybody to take part in the on-farm trials. Seed companies were not producing these seeds to sell to farmers. Furthermore, seed companies are not likely to be interested in producing OPVs. Farmers' response - lack of knowledge – could be interpreted to indicate ineffectiveness of extension communications regarding these cultivars. Inadequate supply and high cost of fertilizer also affected the adoption of the cultivars. Credit facilities would be needed to enable the farmers to purchase necessary inputs (Ogungbile et al. 1998).

Constraints to adoption of S 35 in Chad, as mentioned by farmers, included vulnerability to bird damage (due to early maturity), poor soil fertility, nonavailability of seed and seed cost (Yapi et al. 1999).

There were many reasons for non-adoption in Cameroon. The most important reasons cited by farmers there included losses due to birds, grain mold, high price of milling, light food, regermination of seed, need for fertile soil, poor quality of beer, small stalks for construction, dislike of stalks by animals and lack of seed (Ndjomaha et al. 1998). Several reasons such as losses due to birds, grain mold and regermination of seed are due to the early maturity of S 35, which although helpful when rains cease early, results in increased vulnerability to damage by rain during grain maturation.

The most significant constraints to adoption of improved sorghum cultivars cited by Malian farmers were lack of information about the existence and utility of new varieties (58%), lack of seed (50%) and poor soil (13%). Lack of information and seed were the most important constraints in all three regions, while poor soil was a problem only in Mopti. In Ségou, there was a strong preference for local varieties. In Koulikoro, the need to use fertilizer on improved varieties, their greater vulnerability to bird damage, labor shortages and storage characteristics were cited by farmers as adoption constraints (Yapi et al. 1998).

Based on a farm-level survey conducted across 119 households in southern Honduras in 1990, López-Pereira and Sanders (1992) reported that development of soil conservation technologies would be a necessary precondition for increasing the adoption of improved sorghum cultivars in hillside farming areas of southern Honduras. Another major constraint to adoption was the limited working capital of small farmers. The study suggested that greater access to official credit and better credit conditions for small farmers would be necessary for the adoption of new sorghum cultivars and soil erosion control technologies.

8.7. Lessons from Adoption Studies

Adoption levels of improved sorghum cultivars are high in Asian countries, but comparatively low in African countries. Inter-country comparisons of adoption show that ICRISAT crosses are popular in several African countries. Adoption studies conducted at the farm-, district- and state-levels revealed that adoption of cultivars is related to: (i) the presence of farmers' preferred traits in the new cultivars, (ii) the ease of access to seeds of specific cultivars and/or management options made available when specific cultivars are grown, and (iii) the availability of seeds and the profitability of new cultivars. These have important implications for breeding strategy and for seed delivery systems. The participation of farmers and NARS in all stages of variety selection and development would help ensure that farmers have access to improved varieties with farmer preferred traits. Availability of seed of improved open-pollinated cultivars should be ensured through the participation of farmer cooperatives and public sector seed companies. The involvement of private sector seed companies will be economically attractive and substantial only when hybrid cultivars that provide a reliable and recurring market for seed are available. Therefore, promotion of sorghum hybrids in Asian countries may be possible through broader partnerships and innovative institutional arrangements of public breeding programs with the private sector. On the other hand, promoting OPVs may require stronger involvement of public sector companies and community-level seed production. Availability of source seed (breeder's seed) is a necessary precondition for producing foundation seed and certified seed and their equivalents. It is essential that ICRISAT and its partners lay greater emphasis on the supply of breeder's seed to public and private sector seed companies, and producers of community-level seed.

8.8. References

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