The world sorghum and millet economies

Facts, trends and outlook

International Crops Research Institute for the Semi Arid Tropics

Food and Agriculture Organization of the United Nations

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A joint study by the
Basic Foodstuffs Service
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Socioeconomics and Policy Division
International Crops Research Institute
for the Semi-Arid Tropics

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Summary

Sorghum is the world's fifth most important cereal, in terms of both production and area planted. Millet, a general category for several species of small-grained cereal crops, is the world's seventh most important cereal grain. Roughly 90 percent of the world's sorghum area and 95 percent of the world's millet area lie in the developing countries, mainly in Africa and Asia. These crops are primarily grown in agroecologies subject to low rainfall and drought. Most such areas are unsuitable for the production of other grains unless irrigation is available. Sorghum is widely grown both for food and as a feed grain, while millet is produced almost entirely for food.

The world sorghum economy can be broadly categorized under two production and utilization systems. Intensive, commercialized production, mainly for livestock feed, characterize the developed world and parts of Latin America and the Caribbean. Hybrid seed, fertilizer and improved water management technologies are used fairly widely, and yields average 3-5 t/ha. Such commercialized production systems cover less than 15 percent of the world's sorghum area, but produce over 40 percent of global output. Roughly 40 percent of this grain is traded on international stockfeed markets. In sharp contrast are the low-input, extensive production systems in most of the developing world (with some exceptions in Latin America and the Caribbean), where sorghum is grown mainly for food. While improved varieties are being adopted in such systems, particularly in Asia, management practices generally remain less intensive than in the commercialized systems. Fertilizer rates are low and the adoption of improved moisture conservation technologies is limited. As a result, average yields remain between 0.5 and 1.0 t/ha in many areas.

Millet production systems in Africa and Asia are generally characterized by extensive (rather than intensive) production practices and limited adoption of improved varieties. Yields still average only 0.3 to 1.0 t/ha. While hybrids are being adopted in parts of Asia, most of the world's millet area remains under traditional varieties. Few farmers apply fertilizer or use improved moisture conservation practices.

Sorghum and millet are crucial to the world food economy because they contribute to household food security in many of the world's poorest, most food-insecure regions. In the main production regions in Africa and Asia, more than 70 percent of the sorghum crop and over 95 percent of the millet crop are consumed as food. A large proportion of farm households aim simply to produce enough grain to meet household requirements - and many often fail to meet even this limited goal. Only a small proportion of the harvest is traded, mostly on local food markets.

In *Africa,* the agroclimatic factors most responsible for food insecurity also constrain the adoption of improved technology. Farmers at the margins of subsistence find it risky to invest in new technology. A growing proportion of farmers are beginning to adopt new varieties because only a small investment is required to change seed. However, they are less willing to allocate scarce cash resources to purchase chemical fertilizer or manure. Allocations of capital and family labour required to improve water and nutrient availability to the crop are limited because of the perception of higher returns from alternative farm and non-farm enterprises. For example, investments in schooling compete directly with investments in the cropping system.

In recent years, sorghum and millet production in Africa has expanded mainly due to increases in cropped area. Yields have failed to increase or have even declined because production is being pushed into more marginal areas and poorer soils, even in areas that are already drought-prone. Nonetheless, farmers are expected to begin intensifying production practices as land constraints become binding and the costs of food production shortfalls mount.

Market infrastructure in *Asia* is relatively well developed, especially in areas with high population density. As a result, adoption of improved technology has been earlier and more widespread than in Africa, resulting in significant yield growth over the past three decades. Production systems in the drier and less populated regions are more similar to those in Africa, with unimproved production and management practices, low adoption of improved technology and food insecurity.

Overall, the area planted to sorghum and millet has been declining in Asia. Slow productivity growth and low producer prices have reduced the competitiveness of these cereals, resulting in crop substitution in many areas. In some cases, sorghum and millet have shifted into more marginal lands, where their adaptation to drier, less fertile conditions gives them a comparative advantage over other cereals.

Virtually all the sorghum traded on international markets is used for livestock feed. This is the basis for the more commercialized production systems of the developed world and parts of Latin America and the Caribbean. Global feed utilization of sorghum has declined during the last decade, mainly due to changes in agricultural support policies. However, the prospects for future demand growth for feed

sorghum, particularly in Asia and Latin America and the Caribbean, are expected to strengthen the sorghum economy in these regions.

Small quantities of sorghum are used by commercial food industries in the production of flour, malt drinks and beer. There are good prospects for the expansion of this market if sorghum yields can rise fast enough to catch up with yields of competing cereals, and if marketing costs are kept low.

Millet is traded internationally in small quantities, for use as bird seed, mainly among developed countries. However, this is a thin market with limited prospects for expansion. Millet traded as food is largely confined to cross-border transactions. Future production growth in millet will be used mainly to offset localized food shortfalls.

Food security still represents the primary goal of efforts to improve the world sorghum and millet economies. For most farmers, increased production will translate directly into higher consumption and better nutrition.

As household consumption needs are met, a larger share of production may be traded on regional markets. Thus, higher production and productivity should also mean income growth - particularly important in the major production areas, which are farmed by some of the world's most impoverished populations.

Part I Sorghum

Introduction

Sorghum is one of the main staples for the world's poorest and most food-insecure people. The crop is genetically suited to hot and dry agroecologies where it is difficult to grow other food grains. These are also areas subject to frequent drought. In many of these agroecologies, sorghum is truly a dual-purpose crop; both grain and stover are highly valued outputs. In large parts of the developing world, stover represents up to 50 percent of the total value of the crop, especially in drought years.

Developing countries account for roughly 90 percent of the world's sorghum area and 70 percent of total output (Figs. 1 and 2). Asia and Africa each account for about 25-30 percent of global production (Table 1). Much of the crop is grown by small-scale farming households operating at the margins of subsistence. Production in Africa remains characterized by low productivity and extensive, low-input cultivation. Production is generally more intensive in Asia, where fertilizer and improved seed are used far more widely. On both continents, sorghum is grown primarily for food. In contrast, in the developed countries, almost all sorghum production is used as animal feed.

This categorization i.e., developing countries as food producers and developed countries as feed producers - is generally true, but not always. For example, some developing countries in Latin America and the Caribbean (e.g., Mexico and Argentina) are major producers of sorghum for the feed market (Fig. 1). Correspondingly, this report evaluates production, utilization and trade patterns both regionally and by intensity of the production system. Sorghum production systems fall under two broad groups.

- Group I countries (primarily in Asia and Africa) use sorghum for food. The crop tends to be grown in traditional farming systems; yields generally average less than 1 t/ha and can vary considerably from year to year.

- Group II countries (developed countries and some developing countries) produce sorghum on a commercial basis, primarily for animal feed. The use of modern agricultural practices is widespread, and yields correspondingly average 3-5 t/ha.

Statistical documentation of sorghum production, trade and utilization is generally quite good, especially in countries where production is commercialized. Data are less accurate in countries where sorghum is primarily a subsistence crop, grown in outlying areas.

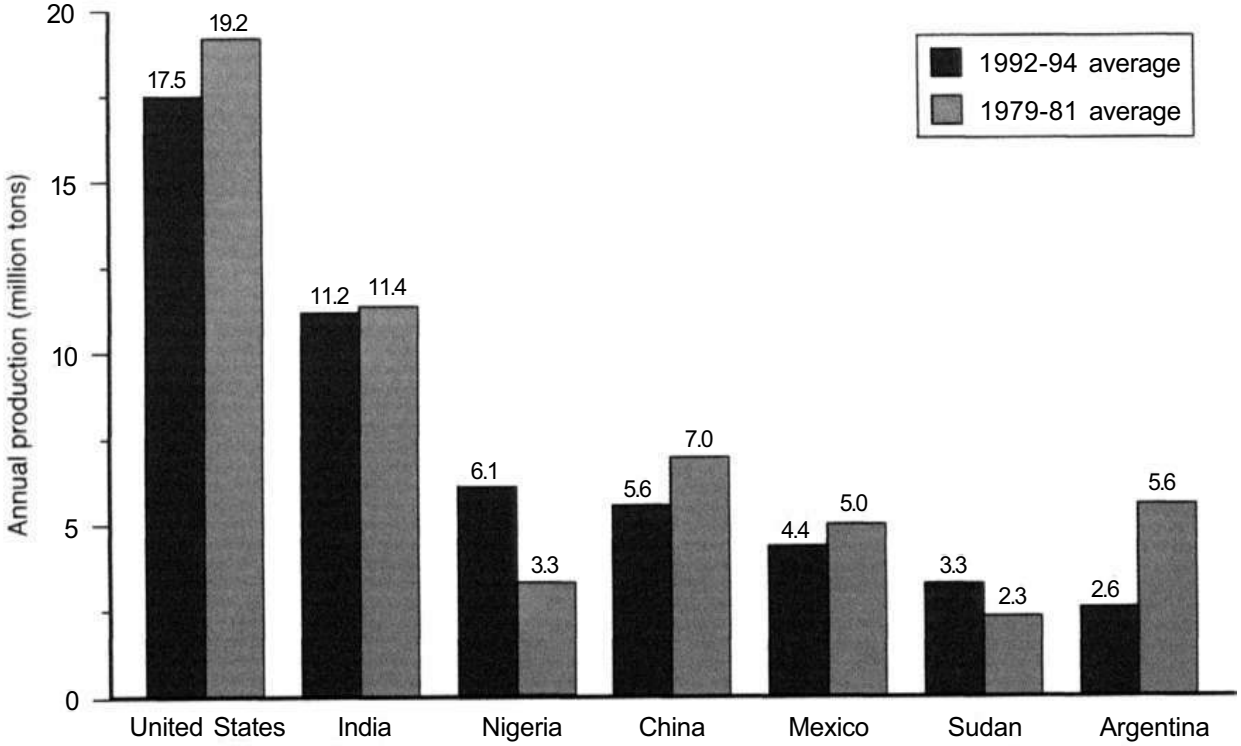


Figure 1. The worlds major sorghum producers.

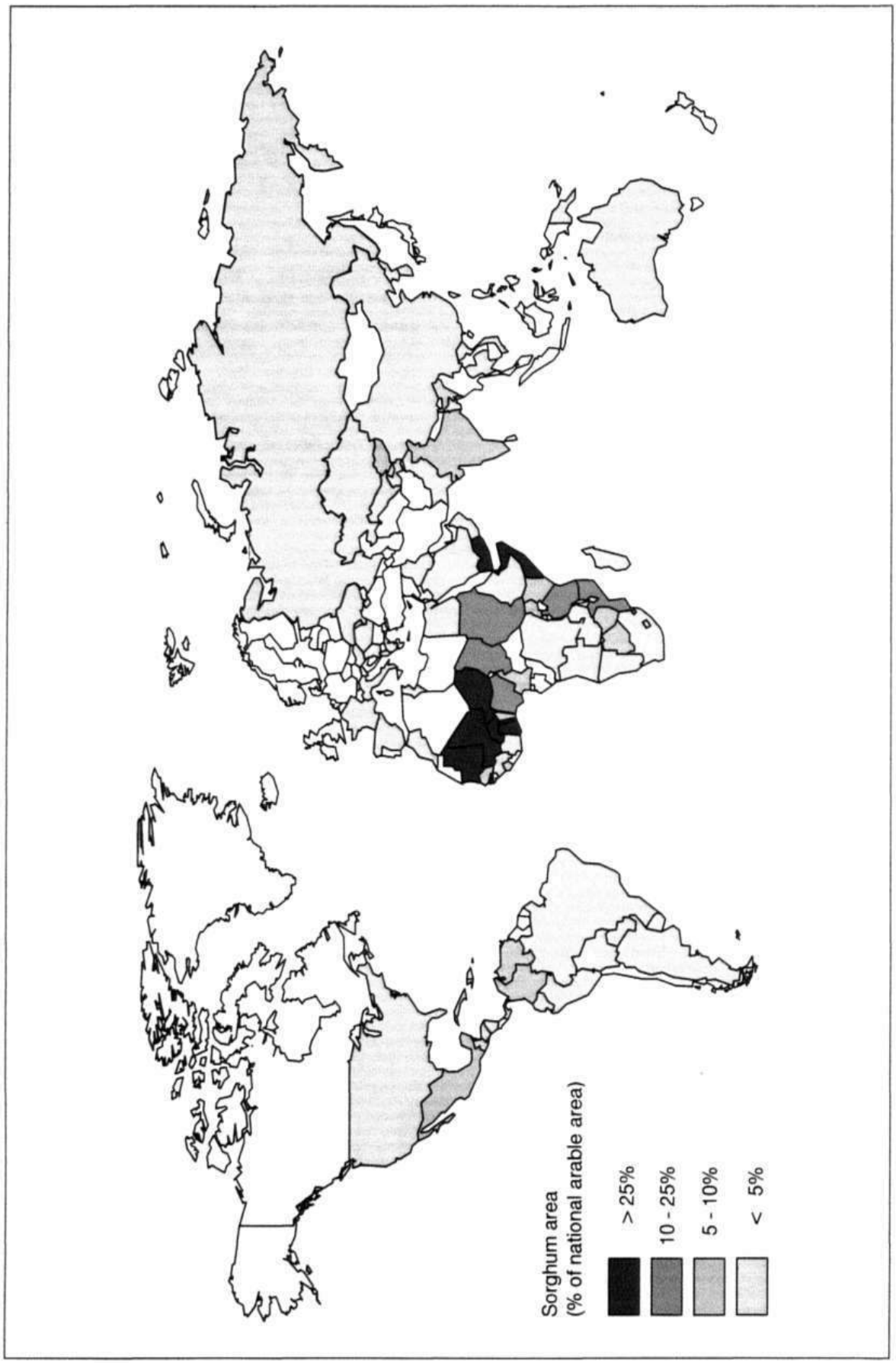


Figure 2. Relative importance of sorghum worldwide.

Table 1. Sorghum area, yield and production by region.[1]

	Area (million ha)			Yield (t/ha)			Production (million tons)		
	1979-81	1989-91	1992-94	1979-81	1989-91	1992-94	1979-81	1989-91	1992-94
Developing countries	**38.60**	**38.30**	**40.00**	**1.14**	**1.04**	**1.11**	**43.90**	**40.00**	**44..20**
Africa	13.40	18.30	21.80	0.89	0.75	0.78	11.90	13.78	17.10
Northern Africa	3.29	4.07	5.95	0.90	0.67	0.69	2.94	2.73	4.10
Sudan	3.05	3.90	5.77	0.74	0.53	0.58	2.27	2.09	3.32
Western Africa	5.70	10.00	11.30	0.89	0.76	0.82	5.10	7.60	9.30
Burkina Faso	1.05	1.32	1.40	0.59	0.75	0.89	0.62	0.99	1.25
Mali	0.43	0.77	0.95	0.78	0.87	0.77	0.34	0.68	0.73
Niger	0.82	2.04	2.26	0.42	0.19	0.18	0.35	0.39	0.42
Nigeria	2.70	4.90	5.70	1.22	0.98	1.07	3.30	4.80	6.10
Central Africa	0.93	1.09	1.21	0.68	0.72	0.74	0.64	0.79	0.89
Eastern Africa	3.23	2.95	3.08	0.95	0.88	0.89	3.08	2.59	2.75
Ethiopia	1.05	0.81	0.91	1.35	1.09	1.27	1.42	0.88	1.16
Kenya	0.17	0.13	0.12	0.95	0.88	1.05	0.16	0.11	0.12
Mozambique	0.29	0.42	0.38	0.63	0.40	0.33	0.18	0.17	0.12
Somalia	0.48	0.45	0.40	0.35	0.54	0.36	0.17	0.24	0.14
Tanzania	0.71	0.53	0.66	0.76	0.99	0.90	0.54	0.53	0.59
Uganda	0.17	0.24	0.26	1.78	1.49	1.50	0.31	0.36	0.38
Zimbabwe	0.14	0.14	0.13	0.61	0.58	0.52	0.09	0.08	0.07
Southern Africa	0.17	0.22	0.19	0.50	0.37	0.39	0.09	0.08	0.07
Asia	20.78	16.56	15.11	0.95	1.03	1.19	19.69	17.00	17.98
Near East	0.92	0.60	0.60	0.81	0.95	1.06	0.75	0.58	0.64
Saudi Arabia	0.28	0.13	0.15	0.44	1.31	1.18	0.12	0.17	0.18
Yemen	0.63	0.47	0.45	0.98	0.85	1.02	0.62	0.40	0.46
Far East	19.85	15.95	14.51	0.95	1.03	1.19	18.94	16.42	17.34
China	2.83	1.55	1.36	2.49	3.31	4.12	7.03	5.13	5.61
India	16.36	13.79	12.55	0.70	0.78	0.89	11.38	10.79	11.23
Pakistan	0.40	0.41	0.40	0.58	0.59	0.59	0.23	0.24	0.24
Thailand	0.22	0.19	0.17	1.07	1.28	1.35	0.24	0.24	0.23
Central America and the Caribbean	1.96	2.07	1.73	2.82	2.73	2.87	5.54	5.64	4.95
El Salvador	0.13	0.12	0.14	1.15	1.27	1.48	0.15	0.16	0.20
Guatemala	0.04	0.06	0.07	1.95	1.41	1.19	0.08	0.08	0.08
Haiti	0.16	0.13	0.11	0.76	0.74	0.78	0.12	0.10	0.09
Mexico	1.49	1.61	1.28	3.35	3.17	3.43	4.99	5.10	4.38
Nicaragua	0.05	0.05	0.05	1.55	1.61	1.80	0.08	0.08	0.09
South America	2.48	1.40	1.38	2.77	2.59	3.08	6.86	3.61	4.23
Argentina	1.87	0.65	0.70	3.02	2.95	3.72	5.64	1.92	2.60
Brazil	0.08	0.16	0.15	2.13	1.54	1.87	0.17	0.25	0.28
Colombia	0.22	0.26	0.22	2.22	2.87	3.08	0.49	0.74	0.69
Uruguay	0.06	0.03	0.04	2.01	2.48	2.97	0.11	0.08	0.11
Venezuela	0.23	0.25	0.21	1.61	2.13	2.10	0.37	0.53	0.44
Developed countries	**6.48**	**5.05**	**4.99**	**3.33**	**3.38**	**3.94**	**21.58**	**17.08**	**19.66**
Australia	0.55	0.46	0.50	1.98	2.16	1.96	1.08	1.00	0.98
EC	0.13	0.11	0.12	4.58	4.90	5.61	0.59	0.56	0.70
South Africa	0.38	0.22	0.18	1.43	1.58	2.05	0.54	0.34	0.37
United States	5.27	4.06	4.05	3.63	3.69	4.32	19.16	14.97	17.50
CIS[2]	0.09	0.15	0.10	1.14	0.76	0.73	0.10	0.11	0.07
World	**45.10**	**43.30**	**45.00**	**1.45**	**1.32**	**1.42**	**65.50**	**57.10**	**63.90**

1. Each figure is a 3-year average for the respective period, e.g., 1979-81.

2. Until 1991, area of the former USSR.

Source: FAO

Crop distribution

In Western and Central Africa, sorghum is grown throughout the belt between the Sahara desert in the north and the equatorial forests in the south (Fig. 2). In Southern and Eastern Africa it is grown in drier regions, where precipitation is too low for the successful cultivation of maize.

Nigeria and Sudan are the major producers in Africa (Table 1), but sorghum is widely distributed, and a key food staple in large parts of the continent. Production in Asia is far more concentrated in geographical terms, with two countries, China and India, together producing 94 percent of the regional total.

Sorghum production in Central America and the Caribbean is dominated by Mexico, which produces 90 percent of the region's total. In South America, production is concentrated in Argentina (60 percent of the regional total) and in the dry areas of Brazil, northern Colombia and Venezuela.

Developed countries produce nearly one-third of the world's sorghum. In North America, it is cultivated in the central and southern plains of the United States (mainly in Kansas, Texas and Nebraska), where rainfall is low and variable. The United States is the world's largest producer, with over 25 percent of global output. Production in Europe is limited to small areas in France, Italy and Spain. In Oceania, Australia is the only producer of significance.

Production Trends

Trends in overall output

Global sorghum production fell by 0.7 percent per annum between 1979 and 1994 (Table 2, and Fig. 3), in contrast to annual increases in the production or other major grains: wheat (1.8 percent), rice (2.3 percent) and maize (1.7 percent). During this period, production grew in Africa (2.9 percent), but declined in most other parts of the world, particularly in North and South America (Table 2).

In the majority of Group I (developing) countries, increases in total output remained below population growth (Table 2). Consequently, per caput production declined during the 1980s before recovering partially in the early 1990s.

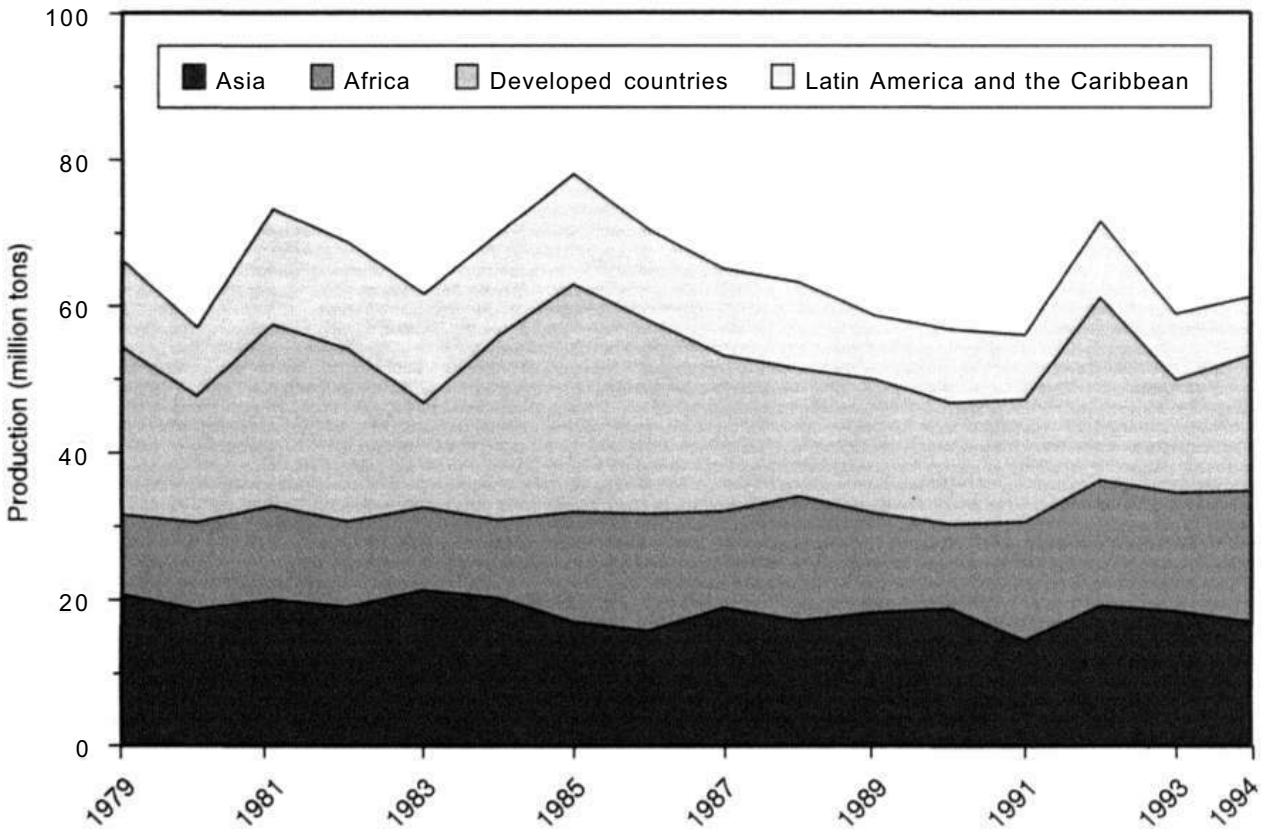


Figure 3. Global trends in sorghum production, 1979-94.

Table 2. Sorghum growth rates, 1979-94.

	Area (%/yr)	Yield (%/yr)	Production (%/yr)	Per caput production (%/yr)
Developing countries	**0.1**	**-0.5**	**-0.4**	**-2.4**
Africa	3.9	-1.0	2.9	0.0
Northern Africa	3.9	-1.1	2.8	0.2
Sudan	4.2	-0.9	3.3	0.8
Western Africa	5.7	-1.2	4.5	1.5
Burkina Faso	2.5	3.2	5.8	2.9
Mali	6.3	-0.1	6.2	4.4
Niger	8.2	-5.9	1.8	-2.2
Nigeria	6.7	-2.1	4.4	1.4
Central Africa	2.1	0.9	3.1	0.0
Eastern Africa	-0.2	-0.6	-0.8	-3.6
Ethiopia	-1.0	-0.7	-1.7	-4.4
Kenya	-1.5	2.4	0.8	-2.7
Mozambique	2.0	-4.9	-3.0	-4.6
Somalia	-1.3	0.6	-0.7	-3.2
Tanzania	0.5	-0.2	0.3	-2.8
Uganda	2.8	-1.0	1.8	-1.5
Zimbabwe	-1.3	1.3	-0.0	-3.2
Southern Africa	3.0	-2.2	0.7	-2.2
Asia	-2.6	1.5	-1.1	-3.0
Near East	-2.8	3.2	0.3	-2.6
Saudi Arabia	-0.9	7.7	6.7	2.3
Yemen	-2.8	1.6	-1.3	-4.7
Far East	-2.5	1.4	-1.1	-2.9
China	-5.8	3.6	-2.5	-3.8
India	-2.1	1.7	-0.5	-2.5
Pakistan	0.1	0.1	0.3	-3.1
Thailand	-2.4	1.5	-0.9	-2.3
Central America and the Caribbean	-0.4	-0.1	-0.6	-2.7
El Salvador	0.5	1.7	2.3	0.8
Guatemala	4.1	-4.0	-0.0	-2.8
Haiti	-2.6	-0.0	-2.6	-4.4
Mexico	-0.4	-0.2	-0.6	-2.8
Nicaragua	0.2	0.0	0.3	-2.5
South America	-5.9	0.6	-5.4	-7.2
Argentina	-9.6	1.4	-8.3	-9.6
Brazil	4.1	-0.9	3.1	1.2
Colombia	0.1	2.8	2.9	1.0
Uruguay	-4.5	3.9	-0.9	-1.4
Venezuela	0.0	2.0	2.1	-0.3
Developed countries	**-2.6**	**1.2**	**-1.5**	**-2.5**
Australia	-1.9	-0.1	-2.0	-3.4
EC	-0.0	1.6	1.5	0.0
South Africa	-4.1	1.8	-2.4	-4.8
United States	-2.7	1.3	-1.5	-2.4
CIS[1]	0.5	-3.5	-3.0	-4.6
World	**-0.2**	**-0.5**	**-0.7**	**-2.5**

1. Until 1991, area of the former USSR

Source: FAO

Within Group I there were two distinct trends. In Asia, production has fallen over the past decade (Fig. 3), largely because of sharp declines in area and production in China. In India, production grew by almost 5 percent per annum during the 1970s, but has remained unchanged during the past decade as sorghum has been replaced by more profitable crops such as pulses and oilseeds. The loss in area was partly compensated by higher productivity obtained by using improved varieties and fertilizer; yields climbed steadily from around 650 kg/ha in the early 1970s to just under 900 kg/ha currently. In Africa, in contrast, production increased, particularly during the first half of the 1980s. This increase was due to area expansion into drier lands as a result of population growth; yields, in fact, *fell* during the period.

In Group II (developed countries, Argentina and Mexico) production fell by almost 40 percent during the latter half of the 1980s, essentially because policy interventions led to reductions in sorghum area. In the United States, output has nearly halved over the past 10 years. During 1985-88, sorghum area in the United States fell from 6.8 million to 3.7 million hectares as a result of two major events.

(i) Farm legislation enacted in 1985 lowered support prices for sorghum compared to cotton or maize (the main competing crops), introduced the interchangeability of sorghum and maize base areas, made crop insurance benefits lower for sorghum, and allowed sorghum growers to idle large areas. Together, these changes encouraged farmers to replace sorghum with other crops.

(ii) Relatively more drought-tolerant maize varieties were developed, and in combination with the increased application of no-tillage technology, allowed the maize belt to extend further west into traditional sorghum land. As a result, universities and private seed companies have cut back on sorghum research.

In Argentina, sorghum production fell from 8 million tons in 1983 to 3 million tons in 1988, because there was a drastic fall in imports by the former USSR[1].

1. The former USSR was a large importer of maize and sorghum from the United States. Following the grain embargo led by the United States in the early 1980s, USSR began importing large quantities of sorghum from Argentina. These purchases fell drastically after the ban was lifted, as price trends favoured the purchase of maize (from the United States).

Trends in area and yields

Sorghum is currently grown on 45 million hectares worldwide (1992-94 average, Table 1). The cropped area is expanding in Africa, where it grew from 13 million to almost 22 million hectares between 1979-81 and 1992-94 (Fig. 4). However, the area is declining elsewhere; global sorghum area fell by 0.2 percent per annum between 1979 and 1994 (Table 2). South America was the most affected, mainly as a result of developments in Argentina.

As for most crops, sorghum yields have risen as new technologies (improved varieties, higher input use, and to some extent better resource management and disease/pest control) were developed and disseminated. The exception is Africa, where yields fell by 14 percent during the 1980s before rising once more in the early 1990s (Fig. 5). In India, yields vary significantly between regions, depending on rainfall, soil type and season. Yields of rainy-season sorghum are 2-2.5 t/ha in areas with deep soils and assured rainfall, but postrainy-season yields are less than 500 kg/ha in many low-rainfall areas.

There are sharp contrasts in productivity between regions: yields (1992-94 average) were 0.8 t/ha in Africa, 1.2 t/ha in Asia, over 4 t/ha in North America, and over 5 t/ha in Europe (Table 1). The reason for these differences is essentially the degree of commercialization and the corresponding adoption of new technologies. Mexico is a good example of dramatic growth created by large-scale commercialization. The sorghum area in Mexico rose from 0.1 million to 1.5 million hectares from the 1960s through the early 1980s. Average yields rose to over 3 t/ha, exceeding the national average for maize by one-third.

In a number of Group II countries, the use of hybrid seed, fertilizer and irrigation have ensured that yields have increased even from a high base level. By contrast, in Group 1, most sorghum is produced on small, fragmented plots; sometimes intercropped, and frequently in areas where soil fertility is low. There is generally limited use of purchased inputs due to financial constraints. However, a few Group I countries (e.g., Sudan and Zimbabwe) produce part of their sorghum on large farms for commercial purposes, using high inputs and sometimes supplementary irrigation. Large commercial farmers in Zimbabwe harvest 2-3 t/ha compared to 400-600 kg/ha by traditional smallholders.

One important factor underlying yield trends is the adoption of hybrids. Hybrids are most widely used in areas where sorghum is produced commercially and in countries with a well-developed private

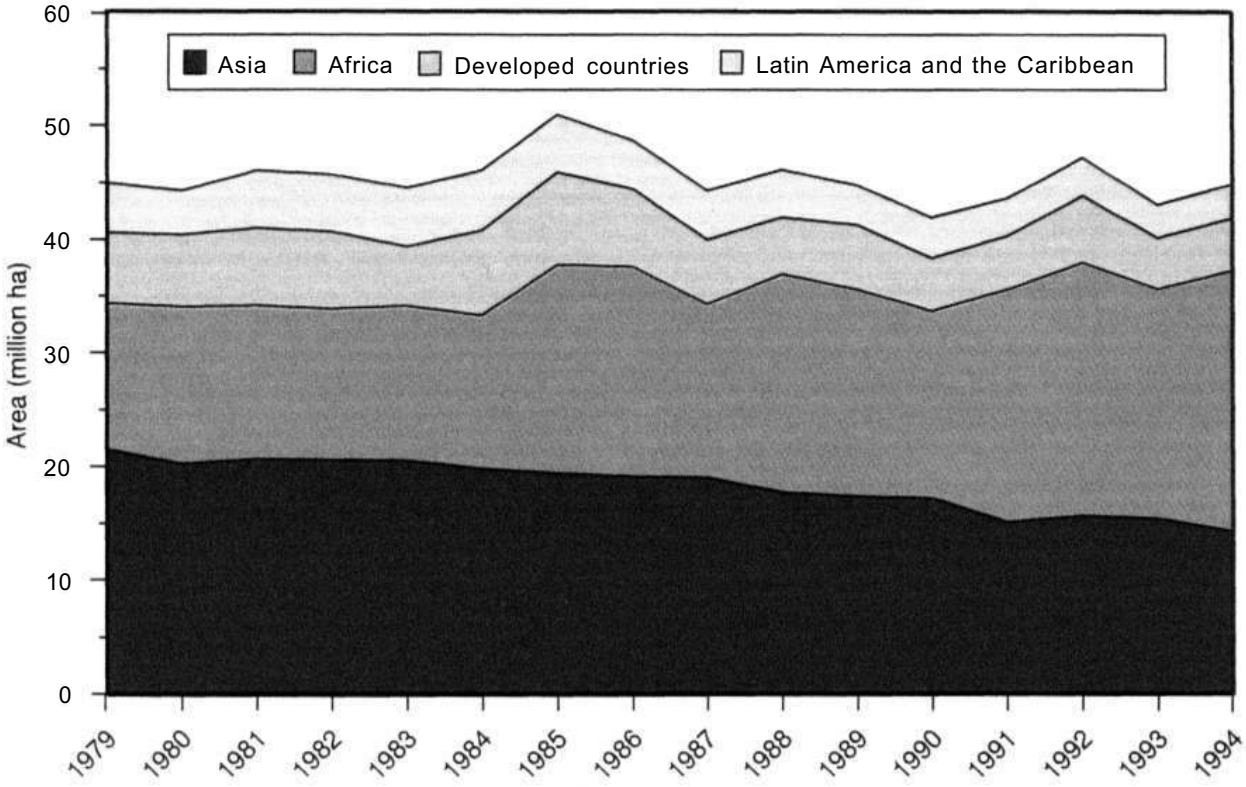


Figure 4. Global trends in sorghum area, 1979-94.

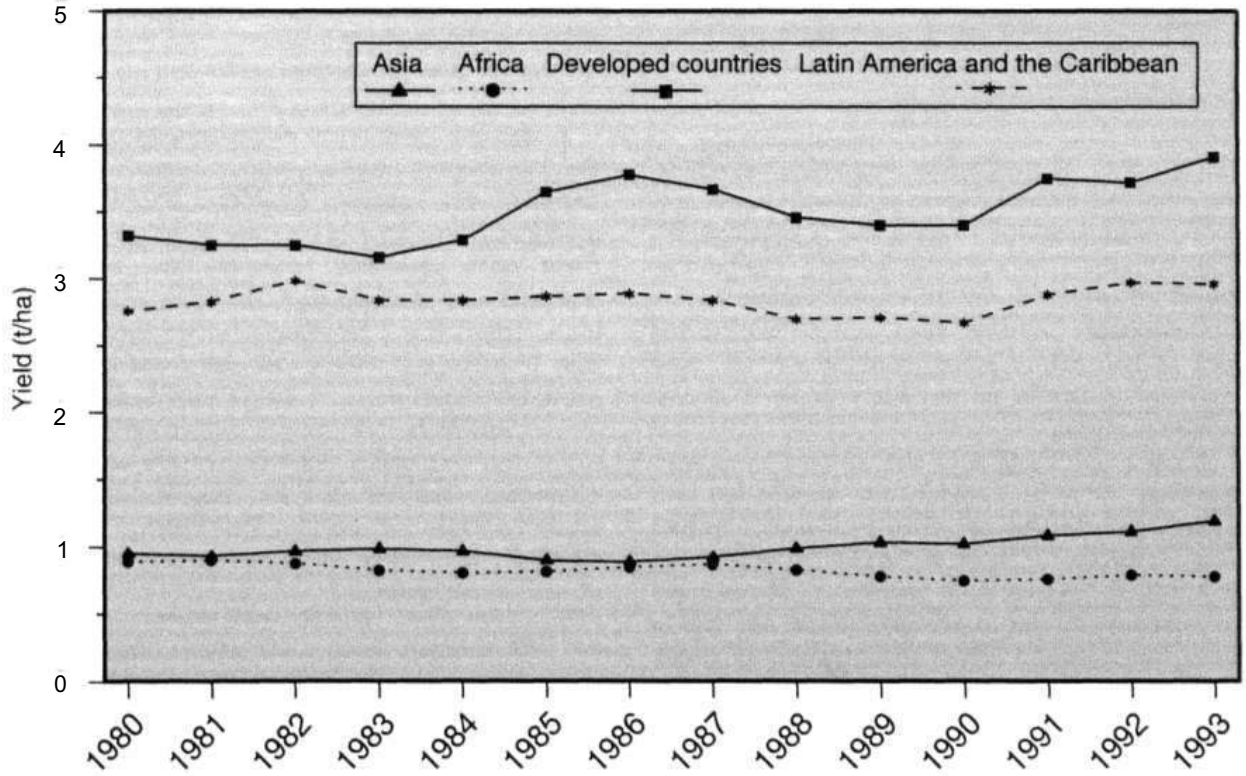


Figure 5. Global trends in sorghum yield, 1979-94 (3-year moving average).

seed industry. Correspondingly, the use of hybrids is concentrated in Group II countries.

In most Group I countries - notable exceptions are China, India, Thailand, Sudan and Zimbabwe - the use of hybrids is negligible. Most hybrids are developed (in Group II) for feed sorghum. However, they are also being developed for the food market in some Group I countries, particularly in India, where they occupy approximately 55 percent of the sorghum area.

Falling yields in Africa, where sorghum is a key food security crop, are a major cause for concern. Population growth has forced an expansion of sorghum area, often into drier, more marginal lands. In some countries, government market policies have encouraged the reallocation of relatively productive sorghum fields to maize. To some extent, this is the result of market policies which have encouraged commercial trade and processing of maize but not of sorghum. In areas where this change has not occurred, fallow periods have often become shorter, giving the land less time to replenish nutrients. Since fertilizer application is generally very low, the net result is a decline in soil fertility. However, although yields have clearly fallen, the decline has not been as sharp as the figures (1.0 percent per year between 1979 and 1994, Table 2) would suggest. This is because the 1979-81 data are for relatively good land, while the 1992-94 figures are for a mixture of "good" and more marginal lands.

Production constraints

The majority of smallholder farmers, especially in the semi-arid tropical regions of Africa, do not produce enough sorghum to meet family requirements in most years. They see sorghum (and crop production in general) as a semi-subsistence enterprise that offers smaller returns than other investments such as livestock or school fees. As a result, they tend not to invest in fertilizers or seed of improved varieties.

Rising labour costs have also affected most farm operations, from land preparation, weeding and bird scaring to harvesting and grain processing. Another factor, important throughout Asia and in urban areas in Africa, is changing food preferences. As incomes rise, consumers tend to purchase wheat, rice and in some cases maize, rather than traditional coarse grains.

In some areas production is constrained by birds, which attack the crop particularly during the grain-filling stage. To minimize bird damage, sorghum with a purple undercoat is cultivated in some countries. The undercoat contains tannins, bitter, stringent substances (polyphenols) that arc distasteful to birds. However, most varieties grown in Africa and Asia do not contain tannin and are, therefore, susceptible to bird damage.

Another major constraint to sorghum production is *Striga,* a parasitic weed that attaches itself to the sorghum roots from where it draws its moisture and nutrient requirements, inhibiting plant growth, reducing yields and in severe cases, causing plant death. Some Striga-resistant sorghum varieties have been developed, but these generally offer lower yields than traditional cultivars and improved (but *Striga*-susceptible) varieties.

Grain moulds cause significant losses in both grain yield and quality, particularly in areas where improved cultivars have been adopted[2]. Other important diseases include anthracnose, charcoal rot, downy mildew, ergot and leaf blight. Insect pests constrain production in many areas. Stem borers are endemic in all areas; head bugs and midge are most important in Western Africa; and shoot fly causes substantial losses in late and off-season sowings in both Asia and Africa.

Another major problem is that variable rainfall leads to large fluctuations in production. Prices fall abruptly in good years, leaving traders reluctant to enter the market, especially since stockholding infrastructure is usually inadequate. This increases the price risk that sorghum producers face, and their unwillingness to invest in commercial sorghum production.

Inadequate government policy support also limits the expansion of sorghum output in many Group I countries. For example, in Africa, as government production support measures for sorghum are relatively small compared to maize, the latter encroached onto sorghum land. In Asia, particularly in India, irrigation and fertilizer subsidies have increasingly favoured rice, wheat and cash crops at the expense of coarse grains, while procurement policies for rice and wheat have helped to increase to a large extent the area under these crops. In a number of developing countries that had long-standing price support policies for sorghum, this support has been drastically reduced or eliminated, mainly as a result of market deregulation.

2. Most improved varieties mature earlier than local varieties, often before the end of the rainy season. This results in increased susceptibility to grain moulds, greatly limiting the adoption of these varieties.

Utilization

Worldwide, total utilization of sorghum fell slightly from 65.4 million tons in 1979-81 to 63.5 million tons in 1992-94 (Table 3). In the early 1980s an estimated 39 percent of global production was used as food and 54 percent for feed. The proportion of food utilization has gradually increased as a result of a greater food use in Africa and the substitution of sorghum by other grains (mainly maize) as feed elsewhere. By 1992-94, 42 percent of total utilization was for food and 48 percent for animal feed.

Food use

Worldwide, approximately 27 million tons of sorghum were consumed as food each year during the 1992-94 period (Table 3), almost the entire amount in Africa and Asia. It is a key staple in many parts of the developing world, especially in the drier and more marginal areas of the semi-arid tropics. Per caput food consumption of sorghum in rural producing areas is more stable, and usually considerably higher, than in urban centres. And within these rural areas, consumption tends to be highest in the poorest, most food-insecure regions.

Sorghum is eaten in a variety of forms that vary from region to region. In general, it is consumed as whole grain or processed into flour, from which traditional meals are prepared. There are four main sorghum-based foods:

- flat bread, mostly unleavened and prepared from fermented or unfermented dough in Asia and parts of Africa;
- thin or thick fermented or unfermented porridge, mainly consumed in Africa;
- boiled products similar to those prepared from maize grits or rice;
- preparations deep-fried in oil.

Per caput consumption of sorghum - and its importance as a food security crop - is highest in Africa. For example, per caput consumption is 90-100 kg/yr in Burkina Faso and Sudan; sorghum provides over one-third of the total calorie intake in these two countries. However, per caput food consumption in Africa has fallen slightly (0.1 percent per annum) between 1979 and 1994 (Table 4), most sharply in Eastern Africa. Sorghum production in Africa rose by 44 percent during this period, but even this increase was not quite sufficient to keep pace with population growth.

During the 1979-94 period, per caput consumption of sorghum declined slightly through the 1980s, as a result of strong production growth. If this growth could be maintained, food security and nutrition levels could be improved substantially in rural areas, where over 90 percent of food sorghum in Africa is consumed.

In Asia, sorghum continues to be a crucial food security crop in some areas (e.g., rural Maharashtra in India, where per caput consumption is over 70 kg/yr). However, both production and food utilization have fallen during the 1980s and early 1990s, because of shifting consumer preferences. As incomes rise, consumers are shifting to wheat and rice which taste better and are easier and faster to cook. This trend is accentuated by rapid urbanization and the growing availability of a range of convenience foods based on wheat and rice.

Government policies in a number of countries have also contributed to the decline in food utilization of sorghum. For instance, imports of relatively cheap wheat and rice by many countries discouraged the consumption of locally produced cereals. In other countries (China and India), government purchases and sales of sorghum under public distribution systems were discontinued, lowering utilization in urban areas. In several countries, consumer subsidies, overvalued currencies or subsidized imports kept prices of wheat and/or rice relatively low, reducing the competitiveness of domestically produced coarse grains. However, structural adjustment programmes and the implementation of the Uruguay Round Agreement are reducing these market distortions in a number of countries.

Animal feed

About 48 percent of world sorghum grain production is fed to livestock (human food use constitutes about 42 percent). In contrast to food utilization, which is relatively stable, utilization for feed sorghum changes significantly in response to two factors: rising incomes, which stimulate the consumption of livestock products, and the price competitiveness of sorghum vis-a-vis other cereals, especially maize. While sorghum is generally regarded as an inferior cereal when consumed as food, the income elasticities for livestock products (and hence the derived demand for feed) are generally positive and high.

Demand for animal feed is concentrated in the developed countries and in middle-income countries in Latin America and Asia, where demand for meat is high and the livestock industry is correspondingly intensive. Over 85 percent of sorghum feed use occurs in Group II (Fig. 6). Three countries (United

Table 3. Sorghum utilization by type and region.

	Direct food (million tons)	Feed (million tons)	Other uses' (million tons)	Total utilization (million tons)	Per caput food use (Kg/yr)
1979-81 average					
Developing countries	**25.0**	**14.7**	**4.4**	**44.2**	**7.7**
Africa	9.0	0.8	2.3	12.1	18.8
Asia	15.7	7.4	2.0	25.1	6.1
Central America and the Caribbean	0.4	7.0	0.2	7.6	3.6
South America	0.1	3.7	0.3	4.1	0.3
Developed countries	**0.3**	**20.4**	**0.6**	**21.2**	**0.2**
North America	0.1	10.5	0.2	10.8	0.5
Europe	0.0	2.8	0.0	2.8	0.0
USSR (former)	0.0	2.5	0.0	2.5	0.0
Oceania	0.0	0.4	0.0	0.4	0.0
World	**25.3**	**35.1**	**5.0**	**65.4**	**5.7**
1989-91 average					
Developing countries	**25.1**	**14.5**	**3.7**	**43.3**	**6.2**
Africa	11.5	0.9	1.8	14.2	18.2
Asia	13.3	6.1	1.6	21.0	4.6
Central America and the Caribbean	0.4	8.4	0.3	9.1	2.7
South America	0.0	2.7	0.2	2.9	0.1
Developed countries	**0.4**	**16.8**	**0.5**	**17.7**	**0.3**
North America	0.2	10.9	0.2	11.3	0.8
Europe	0.0	1.2	1.2	1.4	0.0
USSR (former)	0.0	0.3	0.0	0.3	0.0
Oceania	0.0	0.8	0.0	0.8	0.0
World	**25.5**	**31.3**	**4.2**	**61.1**	**4.8**
1992-94 average					
Developing countries	**26.4**	**14.8**	**5.5**	**46.7**	**6.2**
Africa	12.8	1.3	3.2	17.3	18.6
Asia	13.3	5.6	2.0	20.9	4.1
Central America and the Caribbean	0.4	7.5	0.3	8.3	2.9
South America	0.0	3.1	0.3	3.4	0.1
Developed countries	**0.3**	**15.8**	**0.7**	**16.8**	**0.2**
North America	0.1	11.1	0.3	11.5	0.5
Europe	0.0	1.1	0.2	1.3	0.0
CIS	0.0	0.1	0.0	0.1	0.0
Oceania	0.0	0.8	0.0	0.8	0.0
World	**26.7**	**30.6**	**6.2**	**63.5**	**4.8**

1. For seed, manufacturing purposes and waste.

Table 4. Estimated growth rates of sorghum utilization by type and region, 1979-94.

	Direct food (%/yr)	Feed (%/yr)	Other uses[1] (%/yr)	Total utilization (%/yr)	Per caput food use (%/yr)
Developing countries	**0.3**	**-0.3**	**0.7**	**0.1**	**-1.6**
Africa	2.8	3.7	1.6	2.7	-0.1
Asia	-1.6	-1.5	-1.0	-1.5	-3.4
Central America and the Caribbean	0.6	0.5	3.0	0.6	-1.6
South America	-4.1	-2.3	0.1	-2.1	-6.0
Developed countries	**3.8**	**-2.2**	**1.6**	**-2.0**	**2.7**
North America	0.9	-0.2	1.6	-0.2	-0.1
Europe	-51.7	-4.4	15.4	-3.0	0.0
CIS[2]	0.0	-23.6	2.2	-22.5	0.0
Oceania	-5.5	4.7	51.0	-5.0	-7.4
World	**0.3**	**-1.3**	**0.8**	**-0.5**	**-1.5**

1. For seed, manufacturing purposes and waste.
2. Until 1991, area of the former USSR.

Source: FAO

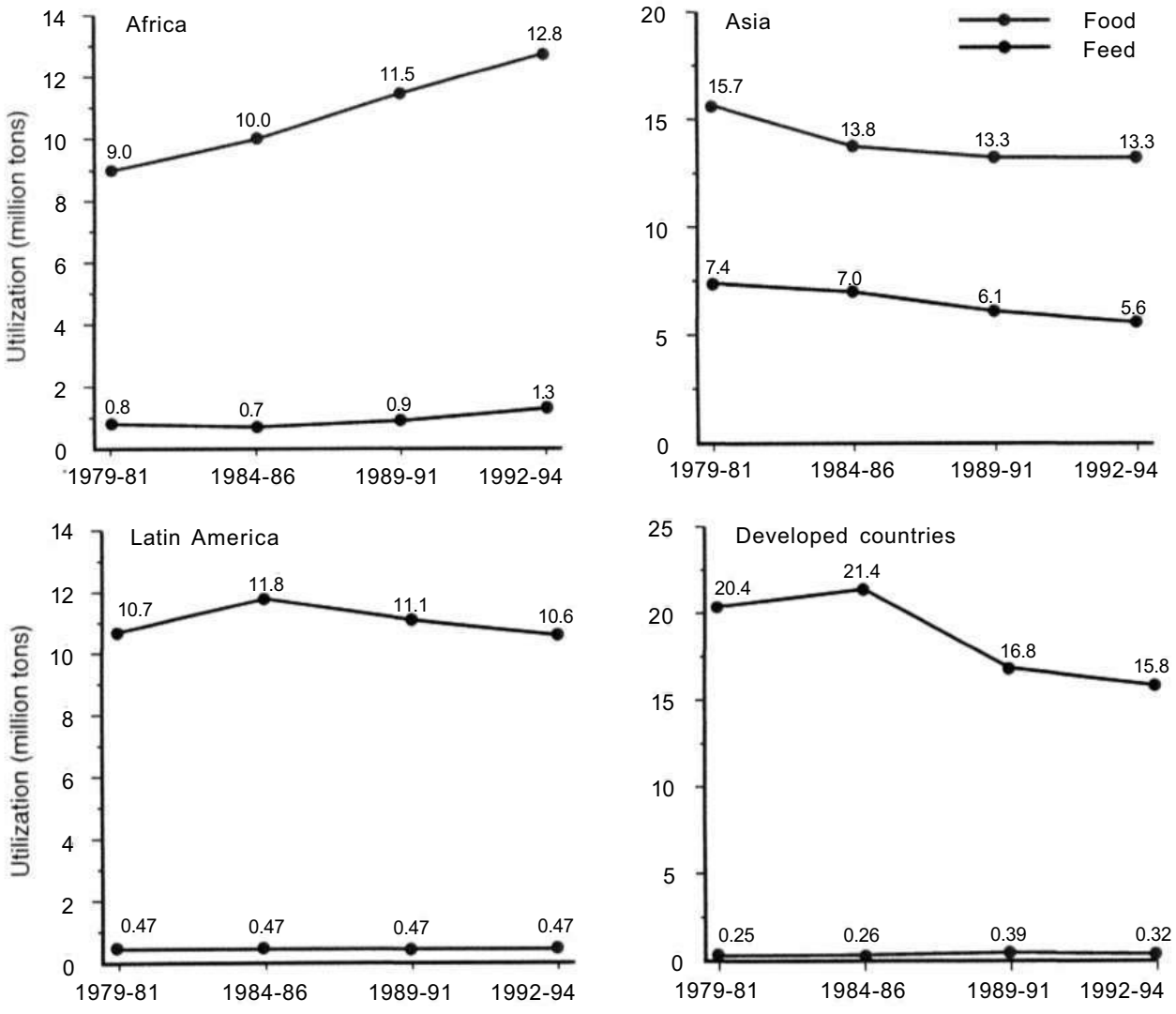


Figure 6. Global sorghum food and feed utilization, 1979-94.

States, Mexico and Japan) together absorb nearly 70 percent of the world total (Table 5).

World feed use rose from 16 million tons at the beginning of the 1960s to about 35 million tons by the mid 1980s, an average growth of 4 percent per annum. This demand was the main driving force in raising global production and international trade during that period. One major factor was increased use of sorghum feed in the United States during the 1960s and early 1970s, largely because the cattle-feeding industry shifted from the northern maize belt to the southern plains, where most United States sorghum is grown. Another factor was sharply rising demand for livestock products in Latin America, particularly in Mexico. In addition, government policies in some Latin American countries (e.g., Venezuela) restricted maize imports.

Trends since then were shaped by two events - response by the former USSR to the United States' grain embargo on sales in the early 1980s, and policy changes in the United States that favoured maize over sorghum. These factors led to an increase in maize production; maize became cheaper than sorghum, and sorghum trade and utilization for animal feed declined. Feed utilization has gradually increased in Africa and remained relatively unchanged in the lower-income countries in Asia. Roughly 5-10 percent of the sorghum produced in India - and a considerably higher proportion in China - is used for livestock and poultry feed. However, both these regions are relatively minor users of feed; changes in utilization trends are driven largely by the Group II countries, particularly the United States.

Sorghum vs maize. Competition between sorghum and maize is a key factor in feed utilization. The feed characteristics of sorghum are very similar to those of other cereals with which it competes. It provides about as much metabolizable energy as maize, has a higher crude protein content (though of lower quality), and is relatively rich in niacin, an essential vitamin. However, large investments in maize research have helped increase yields and reduce growing cycles for this competing energy source. This has improved the competitiveness of maize prices in many countries.

Feed industries in most countries apply least-cost formulations to produce compound feeds, in which sorghum/maize is mixed with non-grain ingredients. The quantity of sorghum used in feed depends primarily on the relative prices of sorghum and maize, and on relative feed value.

Another important factor is consumer preference for meat colour. Maize contains higher carotene levels than sorghum, so meat from maize-fed animals tends to be more yellow than meat from sorghum-fed animals. In Japan for example, consumers generally prefer white-coloured meat. Therefore, sorghum is a valued ingredient in some compound feed rations (for poultry, pigs and some breeds of beef cattle). In contrast, sorghum is discounted by producers in India because consumers there generally prefer poultry meat and egg yolks with a deeper yellow colour.

In addition, farmers in Asia have shown a growing interest in the sale and purchase of sorghum fodder. While the use of sorghum crop residues in Africa remains largely restricted to the farm, there is a large

Table 5. Feed sorghum utilization in selected countries.

	1979-81 average (million tons)	1984-86 average (million tons)	1989-91 average (million tons)	1992-94 average (million tons)
United States	10.5	14.7	10.9	11.1
Mexico	6.7	6.6	8.1	7.1
Japan	4.1	4.2	3.5	2.6
China	2.4	2.1	1.5	1.9
Argentina	2.1	2.5	0.9	1.5
EC	1.8	0.5	0.8	0.9
Australia	0.4	0.3	0.8	0.8
Colombia	0.5	0.5	0.7	0.7
Venezuela	0.7	1.3	0.6	0.4
CIS[1]	2.5	0.9	0.3	0.1
Others	3.4	3.1	3.2	3.2
World	**35.1**	**36.7**	**31.3**	**30.6**

1. Until 1991, area of the former USSR. Source: FAO

and growing market in Asia for traded sorghum residues to meet both rural feed shortfalls and urban agricultural demand, the latter largely for maintenance of dairy animals.

Other uses

Another important outlet for grain sorghum, especially in Africa, is in the preparation of alcoholic beverages. The grain is used for malt or as an adjunct in the production of two types of beer: clear beer and opaque beer, a traditional, low-alcohol African beer that contains fine suspended particles. Although statistics on the quantities of sorghum used in beer preparation are lacking for many countries, the available data indicate that most of this grain is allocated to opaque beer production. Sorghum is traditionally a major ingredient in home-brewed beer, the growing demand for which has created a commercial industry in some countries. This industry produces both opaque beer and dried beer powder for retail sale. Much smaller quantities are used to produce clear beer, primarily in Nigeria and Rwanda. A temporary ban on barley imports in Nigeria during the late 1980s and early 1990s encouraged the development of a market for sorghum-based malt drinks. Small quantities of grain are also used for the production of sweeteners in Nigeria.

Outside Africa, small quantities are used in the beer industries in Mexico and the United States. In China, about one-third of sorghum grain production is reported to be used to make alcoholic beverages, mainly a strong traditional liquor.

Stocks

World sorghum inventories are much smaller than those of other cereals. End-of-season stocks are currently estimated (1994 estimate) at 8 million tons (representing only 3 percent of world cereal stocks), down from 20-25 million tons in the mid 1980s. Although total stocks have fallen, they are now more widely distributed. Until the mid 1980s, usually more than half of world sorghum carryovers were held by the United States. In recent years, United States stocks have declined to less than 20 percent of the world total. China, India and Mexico are now estimated to hold larger inventories.

A large share of global sorghum stocks is also held informally by farmers in Group I countries. These are not fully reflected in official statistics. In regions with high variability of food grain production, particularly in Africa, these stocks sometimes constitute several years of consumption. More commonly, however, household sorghum stocks are much smaller. Most smallholder families can barely produce enough grain for one season's consumption and for seed for the next season. After a bad year, they are forced to purchase food and/or seed from the market or rely on drought relief assistance. Despite the importance of these inventories, accurate data on quantities held and how they are distributed are not available.

International Trade

World trade in sorghum is strongly linked to demand for livestock products, dominated by feed requirements and prices in Group II countries. Only 6 percent of world sorghum trade (about 500,000 tons per year) is for use as food. This is mainly imported by countries in Africa. Since trade is primarily for animal feed, volumes are very sensitive to sorghum/maize price differentials and can fluctuate considerably.

The world market for sorghum currently represents slightly more than 3 percent of global cereals trade. Although most sorghum continues to be consumed in the countries where it is produced, export volumes have risen from 3 million tons in the early 1960s to over 12 million tons (about 20 percent of total output) by the early 1980s (Tables 6 and 7). Most of the expansion took place in the 1960s and the first half of the 1970s, when world trade in sorghum tripled within a period of roughly 15 years, in line with the rise in imports of other coarse grains. Another sharp expansion occurred in the early 1980s, when the former USSR, as a result of the United States' export embargo, started to purchase large quantities of sorghum on the international market. These purchases also narrowed the sorghum/maize export price differential compared with the 1950s and 1960s.

World trade peaked at over 13 million tons in 1985, then fell sharply and remained at around 10 million tons until the early 1990s. It dropped further to about 8 million tons in 1994. This decline was due to a number of factors, including:

- a sharp cutback of production in the United States;
- the narrowed export price gap between maize and sorghum during the 1990s (Fig. 7), which made sorghum less competitive as a feed ingredient;
- the lifting of earlier restrictions or bans on maize imports applied by a number of countries, including Colombia, Mexico and Venezuela.

Table 6. World sorghum imports[1].

	1979-81 ('000 tons)	1984-86 ('000 tons)	1989-91 ('000 tons)	1992-94 ('000 tons)
Developing countries	**3801.6**	**4351.8**	**4901.8**	**4754.3**
Africa	152.4	482.5	305.2	423.7
Northern Africa	0.1	148.3	202.3	196.6
Sudan	0.0[2]	140.1	92.3	191.8
Others	0.1	8.2	110.0	4.9
Western Africa	115.8	198.6	87.1	51.6
Burkina Faso	15.2	13.7	15.8	6.4
Mali	16.7	2.0	13.2	9.2
Niger	18.6	49.7	17.6	19.4
Senegal	23.3	60.0	20.2	9.0
Others	42.0	73.2	20.3	7.6
Central Africa	2.9	17.0	3.9	6.1
Eastern Africa	12.0	57.6	11.8	147.9
Ethiopia	4.1	29.0	6.8	62.0
Kenya	0.1	0.0	1.0	16.8
Somalia	3.7	12.5	3.8	19.0
Zimbabwe	0.0	3.2	0.0	17.1
Others	4.2	12.9	0.2	33.0
Southern Africa	21.6	61.0	0.1	21.5
Botswana	13.9	60.0	0.1	21.5
Others	7.6	1.0	0.0	0.0
Asia	847.7	1158.2	654.0	238.9
China	591.0	657.2	82.4	104.0
Korea, Republic of	72.5	302.9	238.2	82.5
Turkey	0.0	0.0	55.4	0.0
Others	184.3	198.1	278.0	49.4
Latin America	2793.6	2703.9	3330.2	4084.5
Caribbean	4.0	0.0	65.4	3.6
Central America	2111.1	1930.5	2914.0	3990.4
Mexico	2106.9	1922.7	2912.1	3982.2
Others	4.3	7.8	1.9	8.2
South America	678.4	773.5	350.8	90.4
Chile	13.7	6.4	2.2	33.3
Colombia	64.7	68.0	0.7	21.5
Ecuador	0.0	10.3	28.0	10.4
Venezuela	588.6	684.5	315.8	4.5
Others	11.4	4.3	4.1	20.8
Oceania	7.9	7.1	12.4	7.3
Developed countries	**7892.8**	**6942.3**	**5234.5**	**3796.7**
Israel	452.8	500.1	302.3	146.3
Japan	4291.3	4749.0	3843.9	2980.3
South Africa	2.0	9.4	0.4	85.4
EC[3]	1014.2	520.8	617.6	552.9
CIS[4]	1820.2	1160.3	387.7	2.4
Others	312.2	2.6	82.6	29.4
World	**11694.4**	**11294.0**	**9536.3**	**8551.1**

1. Each figure is a 3-year average for the respective period, e.g., 1979-81.
2. Shown as zero for imports less than 50 tons.
3. Including intra-trade among member countries.
4. Until 1991, area of the former USSR.

Source: FAO

Table 7. World sorghum exports[1].

	1979-81 ('000 tons)	1984-86 ('000 tons)	1989-91 ('000 tons)	1992-94 ('000 tons)
Main exporters	**11328.9**	**10856.7**	**8764.3**	**7993.5**
Argentina	3461.3	3144.7	926.5	842.1
Australia	519.8	1200.0	261.2	188.8
China	3.7	439.9	515.8	357.9
United States	7344.0	6072.1	7060.8	6604.7
Others	**1011.4**	**591.6**	**478.4**	**739.4**
Africa	477.9	67.8	164.1	339.2
South Africa	208.5	33.7	11.0	1.4
Sudan	246.2	18.5	136.0	278.7
Others	23.2	15.6	17.1	59.1
Asia	222.2	312.3	57.1	81.9
Thailand	189.4	267.8	55.4	9.2
Others	32.8	44.5	1.8	72.7
Latin America and the Caribbean	54.1	45.5	17.2	38.5
Europe	266.3	165.9	239.9	279.7
EC[2]	251.2	159.5	230.0	272.3
Hungary	7.1	6.4	9.6	7.4
Developing countries	**4001.6**	**3976.4**	**1669.6**	**1658.1**
Developed countries	**8338.7**	**7471.8**	**7573.1**	**7074.9**
World	**12340.2**	**11448.3**	**9242.7**	**8732.9**

1. Each figure is a 3-year average for the respective period, e.g., 1979-81.
2. Including intra-trade among member countries.

Source: FAO

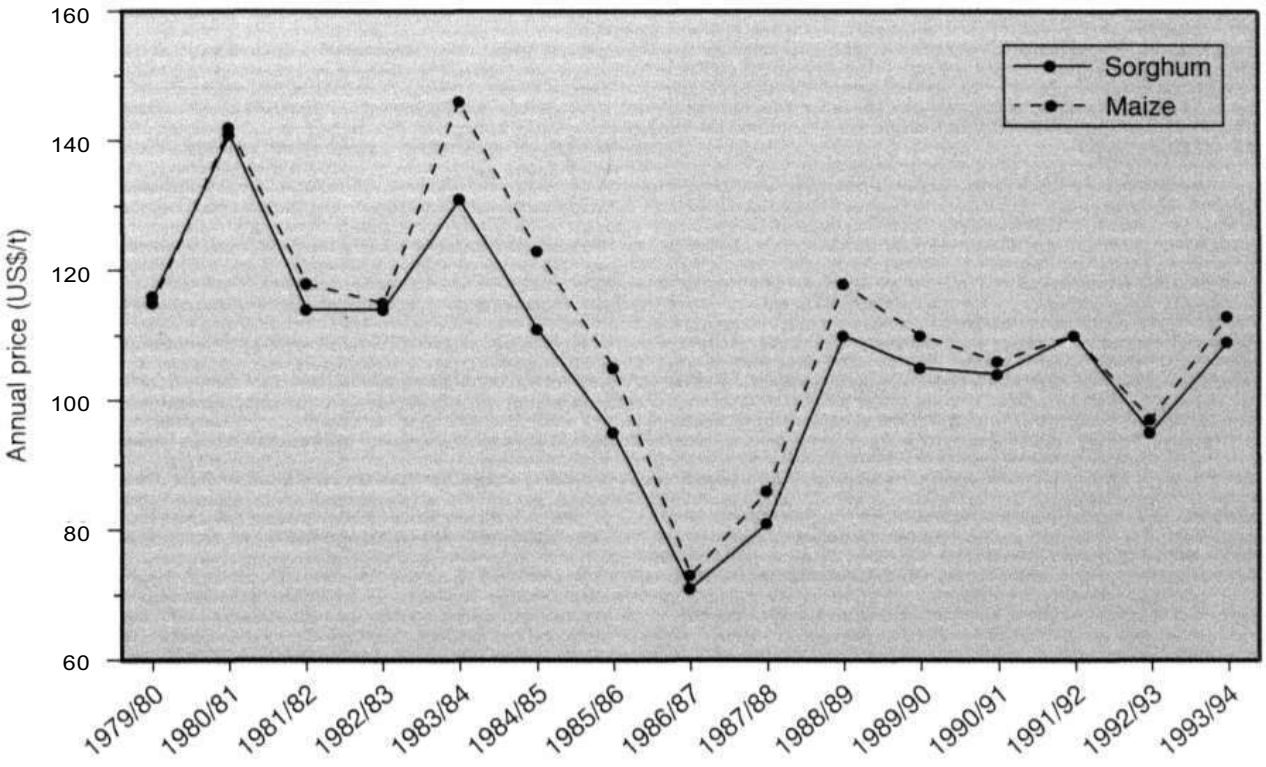


Figure 7. Average annual (July-June) export prices for sorghum and maize at US Gulf ports (Sorghum = US Milo no. 2, yellow; maize = US no. 2, yellow.).

Source: FAO

Imports are concentrated in a few countries - Japan and Mexico alone account for about 80 percent of international imports (Table 6). Another significant importer is the European Community (EC), which, following a long-standing agreement based on the accession of Spain to the EC, is committed to import at least 300,000 tons of sorghum every year[3]. Total sorghum imports worldwide have been falling during the 1980s and early 1990s.

One important trend is that sorghum imports by developed countries have fallen sharply, while those by developing countries have increased considerably in response to growth in livestock production. As a result, the share of developing countries in world sorghum imports has increased substantially, from 3-4 percent in the early 1960s to about 55 percent currently.

The major exporters are Argentina, Australia, China and the United States, which together ship more than 90 percent of the global export volume (Table 7). The United States alone supplies about three-quarters of all exports. Sorghum production and exports from Argentina expanded sharply between the early 1960s and early 1980s. During this period the harvested area rose from 0.8 million to 1.9 million hectares. However, exports fell markedly following a drop in demand during the second half of the 1980s. Australia entered the export market at the beginning of the 1970s, when it started to replace some of its wheat area with sorghum. China became an important exporter by the mid 1980s, but its share in the world market declined recently following a sharp rise in domestic demand for sorghum as animal feed.

The contributions of all the remaining suppliers to world exports are limited. Thailand emerged as a small but regular exporter by the mid 1960s, but rising demand from the domestic livestock industry has reduced exports since the late 1980s. Sudan is a traditional supplier with great potential, but is affected by large year-to-year fluctuations in export availability because of periodic drought.

In the Sahel, good harvests in recent years combined with relatively inelastic domestic demand have led to the emergence of exportable surpluses in a number of countries including Burkina Faso, Mali and Niger. However, strong competition on international grain markets and high assembly and transportation costs make it difficult for these countries to export.

3. This arrangement later became part of the Uruguay Round Agreement.

Developing countries in general, apart from the already established traditional feed grain exporters such as Argentina and China, face a number of problems in exporting sorghum. The volume they have for sale is usually small and not available regularly, and the quality is variable. Moreover, a combination of low yields, high costs of inputs and inland transport and, in some instances, overvalued currencies makes their exports uncompetitive in the highly competitive international market.

The volume of trade between developing countries is limited and often restricted to cross-border and/or triangular food aid transactions. However, official statistics underestimate trade volumes in some regions. Intra-regional trade in Western Africa, for example, is believed to be considerably larger than officially recorded. A substantial portion of the trade between the Sahelian countries, and between some of them and their coastal neighbours, is unrecorded. Similarly, much of the trade between Sudan and its neighbours is unrecorded. This substantial, unofficial trade is caused chiefly by differences in policies (e.g., support prices, foreign exchange rates and government restrictions on trade) between the trading partners,

International Market Prices

International market prices for sorghum are largely determined by the supply and demand situation in the United States, and export prices are based on the reference sorghum, US Milo no. 2, yellow. Since sorghum is almost exclusively traded for feed, market quotations are closely related to price movements for other feed-quality grains, mainly maize, wheat and barley. The prices of feed grains are generally influenced by such factors as world production, the size of carryover stocks and the number of grain-consuming animals. There are no internationally recognized, regularly published prices for white (food) sorghum. Export prices for white sorghum are usually quoted irregularly and only for geographically restricted sub-regional markets, and bear little relation to sorghum (mainly feed sorghum) prices quoted on the international market[4].

4. In 1986, sorghum was sold f.o.b. US Gulf at an average price of US$ 83 per ton. But during the same period, the World Food Programme purchased sorghum at widely varying prices from different suppliers - US$ 117 per ton in Sudan, US$ 261 in Burkina Faso and US$ 263 in Niger. (Source: WFP Occasional Papers no. 11: A study of triangular transactions and local purchases in food aid, Jul 1987).

Export prices were relatively low during the 1960s, when cereal stocks were high, but they more than doubled during the world food crisis of 1972-74. Prices increased from US$ 52 per ton in 1971/72 to US$ 123 in 1974/75. They climbed to another peak of US$ 141 per ton in 1980/81 but remained depressed during the second half of the 1980s and the early 1990s, in line with the level of other coarse grains. They began to increase sharply only in mid 1995 (Fig. 7), after world cereal output remained below global demand for three consecutive years, causing cereal stocks to fall to their lowest level in 20 years.

Competition between different grains for animal feed depends on relative feed values and prices. Although feed values of each grain vary for different types of animals, some rough, general rules have been established. Total digestible nutrients in sorghum are 95 percent of those in maize[5]. Sorghum, therefore, becomes attractive as a feed only when its price declines to below 95 percent of the maize price. Consequently, international sorghum prices move very closely with those of maize, the world's most important feed grain, but are usually slightly lower (Fig. 7).

Internal Marketing and Domestic Policies

In most Group I countries, particularly in Asia and Africa, sorghum is largely a subsistence crop and, therefore, only small volumes enter the marketing chain. Transactions take place mostly in rural markets near areas of production and between neighbouring households. Marketing channels between producers and the major urban centres are poorly developed. The exceptions are India and China, where infrastructure and markets are relatively well developed. Most farmers in India have access to primary wholesale markets; it is lack of demand, not infrastructure, that is the main constraint to production growth.

Domestic markets for sorghum in much of Africa are characterized by limited and variable trade volumes due to scattered and irregular supplies, large distances and high transportation costs. Prices vary during the year; they are lowest immediately after the harvest, when supplies are abundant, and increase as the year progresses. This variation is greatest in countries where sorghum is the main staple (e.g., in the Sahelian zone).

Many Group I countries do not have specific national production or price policies for sorghum. Instead, sorghum is heavily affected by domestic policies for maize, rice, wheat and other cereals. Traditionally, these policies were built around grain prices set by governments or parastatals with a monopoly over grain marketing. Prices were, in most cases, uniform throughout the country and remained fairly constant over the year, irrespective of changing supply or price trends. However, since the mid 1980s, many countries have started to liberalize their cereal markets, removing government price support and direct involvement in grain market management. As a consequence, price variability between different parts of a country and across the year, is expected to increase.

Technological Change, Environmental Issues and Focus of Research

The single most important technological change in sorghum cultivation since the 1960s has been the development and use of *hybrid seed.* Hybrids are now used widely in large parts of the world. Almost the entire sorghum area in Group II countries, and large portions in Group I (except in Africa) are occupied by hybrids. As a result, productivity and uniformity in maturity and grain quality have increased. This has also encouraged mechanization and increased the use of fertilizers and other purchased inputs. In India, where about 55 percent of the sorghum area is sown to hybrids, yields have approximately doubled in the 30 years since hybrids were first introduced.

Issues relating to *sustainability* and the environment are becoming increasingly important. As a result of population pressures in most Group I countries, particularly in Africa, fallow periods are being shortened and more marginal land being brought under cultivation. These marginal lands are farmed with little or no fertilizer, leading to soil degradation. In addition, climate change (lower rainfall, higher temperatures) and periodic drought are making cultivation riskier, forcing farmers in parts of Africa to adopt inappropriate production practices. The net result is falling production and productivity, and production practices that are unsustainable in the long term.

5. Total digestible nutrients in barley and oats are 90 percent and in wheat 105 percent of those in maize.

Another important environment-related issue is infestation by *Striga,* a parasitic weed, several species of which occur in Asia and Africa. Infestation of continuously cultivated fields has become a major constraint to sorghum production in many parts of Africa. The area affected and infestation levels have increased, exacerbated by the drought years of the 1970s and deteriorating soil fertility. Heavy infestation can leave the land unfit for cropping and fields have been abandoned in the worst affected areas. *Striga* currently affects an estimated 8 million hectares in Africa - almost 40 percent of the total sorghum area - and annual yield losses are estimated to be worth over US$ 90 million. The effects are likely to be long lasting as *Striga* plants produce many millions of seeds that can lie dormant in the soil for up to 15-20 years[6]. *Striga* control (using a combination of genetic and management options) is an important research focus, but has so far not been successful. Although several control options have been developed, most are either too expensive or otherwise impractical for smallholder farmers to adopt.

In countries where hybrids are cultivated, there are breeding programmes in place to produce new parent lines and test new grain and forage hybrid combinations. The private sector is a significant contributor to this effort. In many other countries (mainly in Group 1), public sector breeding programmes for open-pollinated varieties have been initiated. Historically, selection was largely for high grain yield, but breeders are now focusing on combining grain yield with grain quality, disease and insect resistance and stover yield. A number of improved varieties have been developed, but dissemination has been poor, especially in Africa, because of inadequacies in seed production and extension support.

Crop management research is conducted in both Group I and Group II. Although the need for such research is most crucial in subsistence farming systems, more attention is directed toward semi-commercial mono-crop systems. A considerable amount of research has been carried out on the individual components of cropping systems or on specific aspects such as fertility management or pest control. Virtually all activities are undertaken by the public sector. However, greater effort is needed on crop-livestock interactions and longer-term sustainability problems. Adaptive research needs to focus on a wider range of solutions that fit the cash constraints and risk perceptions of smallholder farmers.

In most Group I countries, particularly in Africa, breeding and resource management research alone are unlikely to result in major improvements in sorghum production. Technical solutions are available for many existing problems, but improvements in market infrastructure will be required to support more intensified production and break the downward spiral of yields and soil fertility.

It is particularly important to develop the seed market in order to provide farmers consistent access to new varieties and to strengthen input markets to ensure that agrochemicals become cheaper and more easily available. In some countries stabilization of prices is also important, in order to encourage greater investment in sorghum production.

Medium-term Outlook[7]

Production and utilization

World sorghum production is projected to grow at 1.2 percent per year, from 64 million tons per year during 1992-94 to 74 million tons in the year 2005 (Table 8). This notwithstanding, per caput production at the global level - and more important, in countries where it is a vital food security crop - will decline because population will grow faster than production (Table 9).

At the global level, utilization patterns for sorghum are not expected to change substantially over the medium term - the crop will continue to be used primarily for food in Africa and Asia and for animal feed elsewhere. However, there are important regional differences. Food sorghum consumption will grow by about 15 percent between 1992-94 and 2005, driven by a 39 percent increase in Africa. By contrast, food utilization in Asia is expected to drop by 8 percent, in continuation of the current trend.

The feed industry will continue to be dominated by Group II countries. However, the projected 17 percent increase in global feed sorghum utilization will come not from the developed countries, where feed use is expected to *drop* by 10 percent, but from emerging feed sorghum markets in Asia and Latin America.

6. *Striga* also attacks other cereal crops, such as maize and pearl millet, and some legumes, such as cowpea.

7. Covers the period 1992-94 to 2005. The supply outlook is based on estimates of future area and yields projected from recent trends, with some adjustments based on judgement of how individual countries are likely to perform, assuming no major policy changes. Demand projections are based on United Nations population projections and World Bank income growth rates.

Table 8. Projected sorghum production, demand and trade ('000 tons), 1992-94 to 2005.

	Actual (1992-94 average)					Projected (2005)				
	Production	Total use	Food use	Feed use	Trade gap[1]	Productior	Total use	Food use	Feed use	Trade gap[1]
Developing countries	**44,239**	**46,679**	**26,371**	**14,762**	**-2440**	**53,251**	**58,327**	**30,343**	**21,550**	**-5076**
Africa	17,075	16,889	12,660	1,197	186	23,764	21,946	17,633	2,390	1818
Northern Africa	4,099	3,761	2,579	758	338	5,925	5,665	3,556	1,568	260
Western Africa	9,256	9,361	6,944	341	-105	12,861	13,245	9,843	662	-384
Central Africa	894	925	779	7	-31	1,100	1,120	945	13	-20
Eastern Africa	2,753	2,747	2,276	87	6	3,780	3,784	3,172	142	-4
Southern Africa	73	94	82	4	-21	98	131	116	5	-33
Asia	17,975	18,089	13,244	2,973	-114	18,035	19,674	12,172	5,815	-1639
Near East	639	959	459	471	-320	1,007	1,343	648	658	-336
Far East	17,337	17,129	12,785	2,502	208	17,028	18,031	11,524	5,157	-1003
Central America and the Caribbean	4,954	8,265	431	7,504	-3311	6,348	9,363	499	9,123	-3015
South America	4,234	3,437	36	3,088	797	5,104	4,645	38	4,223	459
Developed countries	**19,659**	**16,805**	**318**	**15,807**	**2854**	**20,569**	**15,359**	**370**	**14,281**	**5210**
World	**63,898**	**63,484**	**26,689**	**30,569**	**414**	**73,820**	**73,820**	**30,713**	**35,831**	**134**

1. Production minus utilization.

Source: FAO/ICRISAT

Global feed use is projected to increase from 31 million tons in 1992-94 to 36 million tons by the year 2005. All the expansion is expected to take place in the developing countries, where feed use is projected to rise by 3.2 percent per annum. Asia and Latin America will each account for about 40 percent of the increase in developing countries; growth is expected to be particularly strong in Mexico, Argentina, China and to a lesser extent in India. Africa, where feed demand is expected to *double* by 2005, but from a lower base-value, will account for the remainder. However, Africa's performance will depend on the success of harvests in Egypt and Sudan.

Growth in sorghum demand by 2005 is therefore expected to come from three main sources:

- food use in Africa, fuelled by population growth;
- feed use in Asia, as the livestock industry intensifies in response to rising incomes;
- feed use in Latin America and the Caribbean, as the already highly developed feed industry continues to grow.

One important trend is that the distinction between Group I and Group II will become blurred, as feed markets in developing countries grow. Even so, the crop will remain an essential component of food security in many developing countries, particularly in low-rainfall areas.

In the *developing countries,* production is projected to grow at 1.6 percent per annum from 44 million tons in 1992-94 to 53 million tons in 2005, the rise primarily concentrated in Africa (Tables 8 and 9). This growth will largely result from yield increases, projected at 1.2 percent per annum, from 1.1 t/ha in 1992-94 to 1.4 t/ha in 2005. However, there are important regional differences in growth patterns. In Africa, growth will be driven by increases in both area and yield (the latter despite the fact that much of the expansion will be into marginal lands). In Asia, the area is projected to decline at 1.5 percent per annum as production shifts to other crops. However, production will continue to be maintained by increasing yields.

Between 1992-94 and 2005, food sorghum consumption in developing countries is projected to increase from 26 million to over 30 million tons. During this period, Asia's share of world food sorghum consumption will fall from 50 to 40 percent, while Africa's share will rise from 47 to 57 percent, reflecting its continued dependence on sorghum as a food security crop. Food sorghum utilization in Africa is projected to rise by almost 5 million tons, or just under 40 percent. However, even this substantial increase will still be slower than population growth, leading to a slight fall in per caput consumption.

The medium-term outlook for sorghum (and, therefore, its continued contribution to food security) in Africa will depend on how effectively productivity can be raised by removing various constraints. In Asia, the future will be determined largely by consumption patterns, including changing food prefer-

Table 9. Sorghum projected growth rates, 1992-94 to 2005.

	Area (%/yr)	Yield (%/yr)	Production (%/yr)	Per caput production (%/yr)	Utilization		
					Total (%/yr)	Food (%/yr)	Feed (%/yr)
Developing countries	0.3	1.2	1.6	-0.3	1.8	1.2	3.2
Africa	1.4	1.4	2.8	-0.2	2.9	2.8	5.9
Northern Africa	1.8	1.3	3.1	0.8	3.5	2.7	6.2
Western Africa	1.3	1.5	2.8	-0.5	2.9	3.0	5.7
Central Africa	1.1	0.6	1.7	-1.4	1.6	1.6	4.7
Eastern Africa	1.2	1.5	2.7	-0.6	2.7	2.8	4.2
Southern Africa	2.4	0.1	2.5	-0.6	2.8	2.9	1.9
Asia	-1.5	1.6	0.0	-1.6	0.7	-0.7	5.7
Near East	2.6	1.2	3.9	1.2	2.8	2.9	2.8
Far East	-1.7	1.6	-0.1	-1.7	0.4	-0.9	6.2
Central America and the Caribbean	1.3	0.8	2.1	0.2	1.0	1.2	1.6
South America	0.9	0.6	1.6	-0.1	2.5	0.6	2.6
Developed countries	0.0	0.4	0.4	-0.1	-0.7	1.3	-0.8
World	0.3	0.9	1.2	-0.4	1.2	1.2	1.3

Source: FAO/ICRISAT

ences, and their effect on producer profitability and consumer demand. In Latin America, the key issues will be continued growth of the livestock feed industry and the competitiveness of sorghum relative to maize, determined by environmental and technological factors and the policies governing these two competing crops.

Sorghum production in the *developed countries* is projected to increase only marginally between 1992-94 and 2005 (Tables 8 and 9). This growth will come almost entirely from productivity increases, with area likely to remain at the current level of 5 million hectares. The current decline in feed utilization is expected to continue, due to strong competition from maize and other coarse grains, and because the demand for livestock products, and thus for feed grains in general, is levelling off.

In the United States, which produces roughly 90 percent of the developed countries' sorghum, approximately 18 million tons will be produced in 2005 compared to 17.5 million tons during 1992-94. However, two factors could lead to an increase in sorghum area in the United States:

- declining groundwater levels in the drier parts of the Great Plains, which could encourage farmers to replace less drought-resistant crops with sorghum;
- new legislation that puts sorghum nearly back to full market competition with other cereals.

It is possible that these factors, together with moderate yield increases, will help arrest the decline in sorghum production in the developed countries.

Trade

World trade in sorghum is projected to recover slightly by the year 2005, on the assumption that China is going to cover part of its expected overall increase of coarse grain import requirements with sorghum[8]. Among the developing countries, the Far East will turn from a net exporter (0.2 million tons during 1992-94) to a net importer of about 1 million tons by the year 2005 (Table 8). Changes in the trade volume of other developing regions including Latin America and Africa are likely to be minimal.

Mexico is projected to maintain its current position as the leading sorghum importer at a volume of around 4 million tons per annum. However, Mexico's import demand will depend on domestic policy and on the effects of the North American Free Trade Agreement (NAFTA). Under NAFTA, there will be a continuous increase in the import quota for maize at a reduced customs tariff. Sorghum imports are still duty-free, but this advantage will gradually become eroded.

8. Source: Impact of the Uruguay Round on Agriculture, FAO, Rome 1995.

The developed countries will continue to supply most of the global exports and satisfy a large part of the projected additional imports, especially if the expected partial recovery of production in the United States occurs. Imports by Japan, currently the second largest importer, will continue to fall, in line with its current tendency to import livestock products rather than feed grains.

Summary and Conclusions

The world sorghum economy consists of two distinct sectors - a traditional, subsistence, smallholder farming sector where most production is consumed directly as food (mainly in Africa and Asia), and a modern, mechanized, high-input, large-scale sector where output is used largely as animal feed (mainly in the developed countries and in Latin America). The future of the sorghum economy is linked with its contribution to food security in Africa, income growth and poverty alleviation in Asia and the efficient use of water in drought-prone regions in much of the developed world.

In large parts of Africa, sorghum remains critically important for rural food security. Most production is consumed by the households producing the crop, and only a small proportion of harvests enters the commercial market. Since many sorghum-producing areas still experience periodic food deficits, production must be increased in order to improve household food security. Sorghum area will continue to expand over the foreseeable future as rural populations expand and crop land is extended into drier and more fragile ecosystems. Average sorghum yields, which have been falling by 1.0 percent per annum since the early 1980s, will need to grow in order for food production to keep pace with population growth.

Improvement of sorghum productivity in Africa depends on the development and availability of new technologies and on institutional reforms needed to improve input flows to farmers and stimulate the sale of grain products. Technological change is already being led by the introduction of new varieties, particularly in Mali and Burkina Faso. Breeding programmes have offered a range of new varieties that improve yields and provide greater flexibility in sowing dates. However, in most countries, seed production and distribution constraints restrict the access of farmers to these new varieties. Private sector seed companies have proven reluctant to market open-pollinated sorghum varieties, and public sector seed industries are generally deficient. The payoff to past investments in breeding depends on resolving these constraints.

The largest gains in sorghum productivity will need to be found in technologies that improve the plant's access to water and nutrients. Sorghum crops throughout Africa generally receive little or no fertilizer. Application of manure is restricted by limited supplies and the competition for this input among various crops. Farmers tend to judge technologies required for water conservation to be too labour demanding and uncertain in their payoff. Yet as the continent's land frontier dissolves and population densities rise, it will become even more critical for farmers to intensify production. However, this will happen only if farmers perceive that returns on investment in new technologies (e.g., to improve fertility and water conservation) are comparable with returns from other investments. Scientists and extension workers can encourage farmers to invest in new technology by offering them a wider range of options for soil and water management to fit variable investment strategies and risk preferences.

Continued investment in technologies to ensure stability of grain yield and quality will also be required in Asia. In particular, integrated pest and disease control strategies will be needed. Past investments on insect pest resistance arc set to yield returns in the near future in the form of shoot fly and midge-resistant hybrids for parts of Asia; but resistant hybrids will probably need to be used in combination with management control options. Grain moulds will remain a problem that is unlikely to be solved through host-plant resistance in the foreseeable future; other control options must be developed.

Pest and disease pressures will need to be attacked through chemical, biological and management control. *Striga* losses appear to be increasing. While breeders are pursuing a solution through new resistant cultivars, more effective control will probably need to be obtained from management strategies. The most promising solution is fertility improvement, but this requires farmers to either invest in fertilizer or forego some sorghum by introducing a legume as a rotation crop. Researchers need to modify these solutions to make them less expensive. Similarly, further investment is required to develop integrated pest management strategies for major insect pests such as stem borer, midge and head bugs.

The prospects for greater sorghum trade are constrained by the variability of production levels and high costs of collection and transport from outlying production areas. Trade prospects over longer distances may best be developed in areas where produc-

tivity is higher and more consistent. In countries where sorghum is the dominant food crop, policies, compatible with the Uruguay Round commitments, remain necessary to reduce price fluctuations in the domestic market. In countries where sorghum is regionally important, policy support is needed to encourage sorghum flows from surplus to deficit areas. This may involve the strengthening of market information systems or the provision of investment incentives for rural grain traders. Such interventions would more than justify the investment required, because they are likely to significantly improve food security and offset drought relief costs in the future.

The prospects for expanding sorghum use as a feed grain depend largely on the location of the stockfeed industry relative to production areas, and the speed of its expansion. Once food demands are met, the prospects for growth in feed demand are high. Despite the large interest generated in the use of sorghum for processed foods and bakery products, industrial utilization remains limited. Small quantities of sorghum are used in the production of beer malt, starch and flour in several African countries, e.g., South Africa and Nigeria. However, food industries tend to be conservative in experimenting with alternative inputs, and the prospects for industrial use are sharply constrained in most countries by uncertain supplies and variable grain quality. Further, in some countries, regulations make it illegal for the food industry to use sorghum as a low-cost alternative to other cereals (e.g., in Mexico, it is illegal to use sorghum in tortilla manufacture in place of maize).

In Asia, sorghum remains important as a subsistence crop, though in an increasingly commercialized production system. The largest share of production is still consumed on the small-scale farms where it is harvested. However, growing proportions are also being sold on village and urban markets. The future of sorghum in Asia depends on its competitiveness with alternative cash crops. Once household food needs are met, land is being shifted to crops with more favourable market prospects. Recent trends in countries like India suggest that sorghum land is now being reallocated to the production of more remunerative crops, such as pulses and oilseeds. These other crops are often more remunerative because of policy changes that have successfully stimulated their production. As long as food production deficits remain limited, these trends are expected to continue.

In the more commercialized Asian production systems, the prospects for further improvements in sorghum productivity appear highly favourable. China, where sorghum yields now average over 4 t/ha, has led this change. In India, the region's largest producer, yields still average less than 1 t/ha. Growth is most likely to be obtained by accelerating the shift from open-pollinated varieties toward hybrids. In addition, farmers need to improve the availability and efficiency of soil nutrients through greater application of inorganic fertilizers. Efficiencies in fertilizer use can be obtained through better targeting of micronutrients.

The pursuit of these productivity gains is particularly important because they will translate directly into income gains for some of the poorest rural households on the continent. In effect, productivity growth in sorghum represents a self-targeting source of poverty alleviation.

Higher yields are likely to translate into improved competitiveness for sorghum on Asia's industrial markets. Depending on the price and quality of competing inputs, there are prospects for expanding sorghum's use as a source of starch, as an input to beer production and as a compositing agent in various types of bakery products. However, the greatest source of growth in utilization will probably be the stockfeed industry. As incomes rise throughout Asia, the demand for milk, meat and other animal products, and, therefore, for stockfeed, is rising sharply. In some of the fastest growing economies, this demand has been met by sorghum and maize grain imports. Domestic production could replace these imports. In major producers such as India, the stockfeed market offers the prospect of large growth in demand for both grain and fodder products.

In the major feed-producing countries, sorghum production appears increasingly variable as a result of agricultural policy interventions, the relative demand for stockfeed and the competitive market position of alternative stockfeeds such as maize. Several developing countries with rapidly growing feed sectors have experienced strong production growth, most of which has occurred in the modern, mechanized sector where yields usually exceed 3 t/ha. In developed countries, although yields continue to grow, area sown has been variable. The decline in sorghum area in the United States, the world's largest producer, could well be reversed as policy interventions favouring maize are terminated.

A key issue for the future is whether sorghum will remain competitive with maize in the feed grain market. This will depend primarily on the relative growth of productivity in the two crops. While maize breeders are working to develop more drought-tolerant varieties, the prospects for achieving the levels of tolerance inherent in sorghum are limited. Rising global water constraints and rising water costs

appear likely to encourage the allocation of a growing share of feedcrop land to sorghum. This trend may be accelerated by improvements in the nutrient-use efficiency of the sorghum plant.

On balance, sorghum will remain a key food security crop in Africa for the foreseeable future. Productivity gains are essential to offset the prospects of continuing food production shortfalls in most semi-arid regions and the prospects of periodic famine in some. This in turn requires greater investment in technology development and dissemination. In Asia, sorghum will remain important for household food supplies, but may become increasingly used as stockfeed. Productivity gains will translate into income growth as farmers either shift land to more remunerative cash crops or target sorghum production for the commercial market. Since most sorghum is still grown by poorer small-scale farmers, investments in research and extension will contribute directly to poverty alleviation. And in most middle and higher-income countries, sorghum will remain important as a feed grain uniquely suited to commercial production in hot, dry and drought-prone regions.

Part II Millet

Introduction

Millet is a collective term referring to a number of small-seeded annual grasses that are cultivated as grain crops, primarily on marginal lands in dry areas in temperate, subtropical and tropical regions. The most important species are pearl millet, finger millet, proso millet and foxtail millet (see Annex I for types of millet). Pearl millet accounts for almost half of global millet production. It is the most important species of millet both in terms of cropped area and contributions to food security in regions of Africa and Asia that can produce little else. Finger millet is widely produced in the cooler, higher-altitude regions of Africa and Asia both as a food crop and as a preferred input for traditional beer. Proso millet is important for bird seed in the developed countries and for food in parts of Asia. Foxtail millet is important in parts of Asia (mainly China) and Europe. The other species (barnyard, kodo and little millets, the fonios and teff) are locally important food grains restricted to smaller regions or individual countries. The various species differ in their physical characteristics, quality attributes, soil and climatic requirements and growth duration.

Developing countries, mainly in Asia and Africa, account for about 94 percent of global output, estimated at some 28 million tons (1992-94 average, Table 1). Of this, pearl millet accounts for about 15 million tons, foxtail millet for 5 million tons, proso millet for 4 million tons and finger millet for over 3 million tons (Annex II). Almost all millet is produced by small-scale farmers for household consumption and localized trade. Pearl millet, in particular, is critically important for food security in some of the world's hottest, driest cultivated areas.

Very limited quantities of millet are produced in the developed countries, primarily for a high-value specialty market as bird seed. Correspondingly, only limited quantities of millet are recorded in international trade.

Statistical documentation for millet is generally poor and fragmentary. Few national statistics distinguish between the various botanical species. Some countries combine millet figures with those of sorghum and other cereals, and include millet under the general category "other coarse grains". Many of the statistics are only rough estimates; analyses derived from these data should, therefore, be treated with caution.

Millets are better adapted to dry, infertile soils than most other crops, and are therefore often cultivated under extremely harsh conditions - for example, high temperatures, low and erratic precipitation, short growing seasons and acidic and infertile soils with poor water-holding capacity. Most millets have strong, deep rooting systems and short life cycles, and can grow rapidly when moisture is available. As a result, they can survive and reliably produce small quantities of grain in areas where mean annual precipitation is as low as 300 mm. This compares with a minimum water requirement of 400 mm for sorghum and 500-600 mm for maize. Some species (pearl and proso millets) also appear to tolerate higher temperatures than sorghum and maize, although they do not tolerate long drought periods as well as sorghum.

Millet production systems

In most parts of the world, millet is grown as a subsistence crop for local consumption. Commercial millet production is risky, especially in Africa, because the absence of large market outlets means that fluctuations in output cause significant price fluctuations, particularly in areas where millet is the main food crop. Apart from grain production, millet is also cultivated for grazing, green fodder or silage. Livestock are an important component of most millet production systems, and millet crop residues contribute significantly to fodder supplies. Some popular landrace varieties in India, for example, are over 3-meter tall, and are valued for the large amount of fodder they provide, even though grain yields are relatively low[1].

In developing countries, millet cropping systems tend to be extensive, with limited application of improved technologies, except in some of the more commercialized farming regions in India. These crops are usually grown without irrigation or chemical fertilizer, on light, well-drained soils that are poor in organic matter content. When supplementary or full irrigation is available, farmers prefer to cultivate more remunerative crops, although exceptions occur in some regions (such as Gujarat in India) where there is seasonally high demand for pearl millet crop residues as fodder for milch animals. Short-duration millet cultivars are also grown under irrigation, before or after higher-value crops, in areas where the season is long enough to permit double cropping.

For these reasons, and others discussed in the section on Production Trends, millet yields are usually

1. Dry millet stover often has a lower total fodder value than stover from sorghum or other grains because the stalks are lignified and have a lower digestible energy content. However, it is often the only fodder available in areas where millet is grown.

Table 1. Millet area, yield and production by region.[1]

	Area (million ha)			Yield (t/ha)			Production (million tons)		
	1979-81	1989-91	1992-94	1979-81	1989-91	1992-94	1979-81	1989-91	1992-94
Developing countries	**34.70**	**34.40**	**35.60**	**0.68**	**0.73**	**0.75**	**23.67**	**25.00**	**26.60**
Africa	11.50	15.80	18.50	0.67	0.66	0.61	7.68	10.46	11.36
Northern Africa	1.10	1.05	1.96	0.40	0.18	0.28	0.44	0.19	0.55
Sudan	1.10	1.05	1.95	0.40	0.18	0.28	0.44	0.19	0.55
Western Africa	8.30	12.60	14.00	0.67	0.68	0.64	5.52	8.55	9.00
Burkina Faso	0.80	1.21	1.24	0.49	0.54	0.64	0.39	0.65	0.79
Ghana	0.18	0.19	0.20	0.64	0.64	0.82	0.12	0.12	0.17
Cote d'Ivoire	0.06	0.08	0.08	0.58	0.61	0.84	0.04	0.05	0.07
Mali	0.64	1.19	1.20	0.72	0.69	0.61	0.46	0.82	0.73
Niger	3.01	4.19	4.87	0.44	0.34	0.38	1.31	1.43	1.86
Nigeria	2.40	4.50	5.20	1.04	1.04	0.89	2.50	4.67	4.62
Senegal	0.93	0.90	0.89	0.60	0.64	0.61	0.56	0.58	0.55
Togo	0.12	0.13	0.13	0.36	0.51	0.50	0.04	0.07	0.06
Central Africa	0.63	0.79	0.93	0.59	0.51	0.48	0.37	0.40	0.45
Cameroon	0.13	0.06	0.05	0.75	1.06	1.01	0.10	0.06	0.06
Chad	0.36	0.54	0.59	0.50	0.40	0.47	0.18	0.22	0.28
Eastern Africa	1.46	1.33	1.46	0.89	0.97	0.91	1.31	1.29	1.33
Ethiopia	0.23	0.25	0.25	0.90	0.95	1.05	0.20	0.24	0.27
Kenya	0.08	0.10	0.09	1.05	0.67	0.65	0.08	0.07	0.06
Tanzania	0.45	0.23	0.32	0.80	0.94	0.71	0.36	0.22	0.23
Uganda	0.30	0.38	0.41	1.59	1.53	1.57	0.47	0.58	0.63
Zimbabwe	0.35	0.27	0.25	0.43	0.50	0.27	0.15	0.14	0.07
Southern Africa	0.09	0.11	0.21	0.41	0.49	0.18	0.04	0.06	0.04
Asia	22.98	18.29	16.99	0.69	0.79	0.89	15.75	14.45	15.17
Near East	0.19	0.18	0.15	1.02	0.58	0.78	0.19	0.10	0.12
Far East	22.79	18.41	16.84	0.68	0.78	0.89	15.56	14.35	15.05
China	3.98	2.25	1.90	1.45	1.74	1.93	5.79	3.92	3.67
India	17.84	15.19	13.95	0.51	0.64	0.77	9.19	9.76	10.70
Myanmar	0.18	0.17	0.20	0.45	0.69	0.66	0.08	0.12	0.13
Nepal	0.12	0.20	0.21	0.99	1.16	1.14	0.12	0.23	0.24
Pakistan	0.51	0.44	0.43	0.50	0.41	0.44	0.25	0.18	0.19
Central America and the Carribean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
South America	0.20	0.04	0.04	1.21	1.49	1.53	0.25	0.06	0.06
Argentina	0.20	0.04	0.04	1.21	1.49	1.53	0.25	0.06	0.06
Developed countries	**2.94**	**4.13**	**2.49**	**0.65**	**0.88**	**0.72**	**1.93**	**3.64**	**1.79**
Australia	0.03	0.03	0.03	1.00	0.88	1.05	0.03	0.03	0.03
United States	0.09	0.15	0.15	1.20	1.20	1.20	0.11	0.18	0.18
CIS[2]	2.79	3.92	2.27	0.63	0.87	0.68	1.76	3.40	1.54
World	**37.60**	**38.60**	**38.10**	**0.68**	**0.74**	**0.74**	**25.70**	**28.65**	**28.38**

1. Each figure is a 3-year average for the respective period, e.g., 1979-81.

Source: FAO

2. Until 1991, area of the former USSR.

much lower than yields of other cereals (which are grown under more favourable conditions). Although millet occupies about 5 percent of the world's cereal area, it accounts for only 1.5 percent of world cereal production. Furthermore, yields are highly variable from one season to another. In Niger, for example, average pearl millet yields fell from 510 kg/ha in 1988 to 240 kg/ha in 1990, then increased to 360 kg/ha in 1992.

Crop distribution

In Asia, millet is restricted almost exclusively to two countries, India and China, although Myanmar, Nepal and Pakistan also produce small quantities. India is the world's largest producer, harvesting about 11 million tons per year, nearly 40 percent of the world's output (Fig. 1). Pearl millet, which accounts for about two-thirds of India's millet production, is grown in the drier areas of the country, mainly in the states of Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana. Finger millet is produced mainly in the state of Karnataka, but also in Orissa, Uttar Pradesh and Tamil Nadu. It is also the most important millet in Nepal and Bhutan. China produces about 3.7 million tons of millet (mainly foxtail) per year, largely in the provinces of Hebei, Shanxi and Shandong.

Millet production in Africa (Fig. 2) is distributed among a much larger number of countries, notably Nigeria (over 40 percent of the regional output), Niger, Burkina Faso, Mali, Senegal and Sudan (Table 1). Pearl millet is grown along the southern peripheries of the Sahara (i.e., the Sahelian countries and the northern parts of the coastal countries in Western Africa) and in the drier areas of Eastern and Southern Africa. Finger millet production is concentrated in Eastern and Southern Africa, where the leading producers arc Uganda and Tanzania. As a grain crop, tef is largely confined to Ethiopia. Small quantities of white fonio are grown throughout sub-Sahelian Western Africa, most importantly in Mali. Black fonio is grown in isolated pockets in Nigeria, Togo and Benin. Guinea millet is cultivated only on the Fouta-Djallon plateau of northwestern Guinea and adjacent Sierra Leone. Foxtail and proso millets are very minor crops in Africa, but are cultivated to a limited extent in Kenya and other upland areas in Eastern Africa. Kodo millet is commonly harvested from wild forms in Western Africa, but cultivated

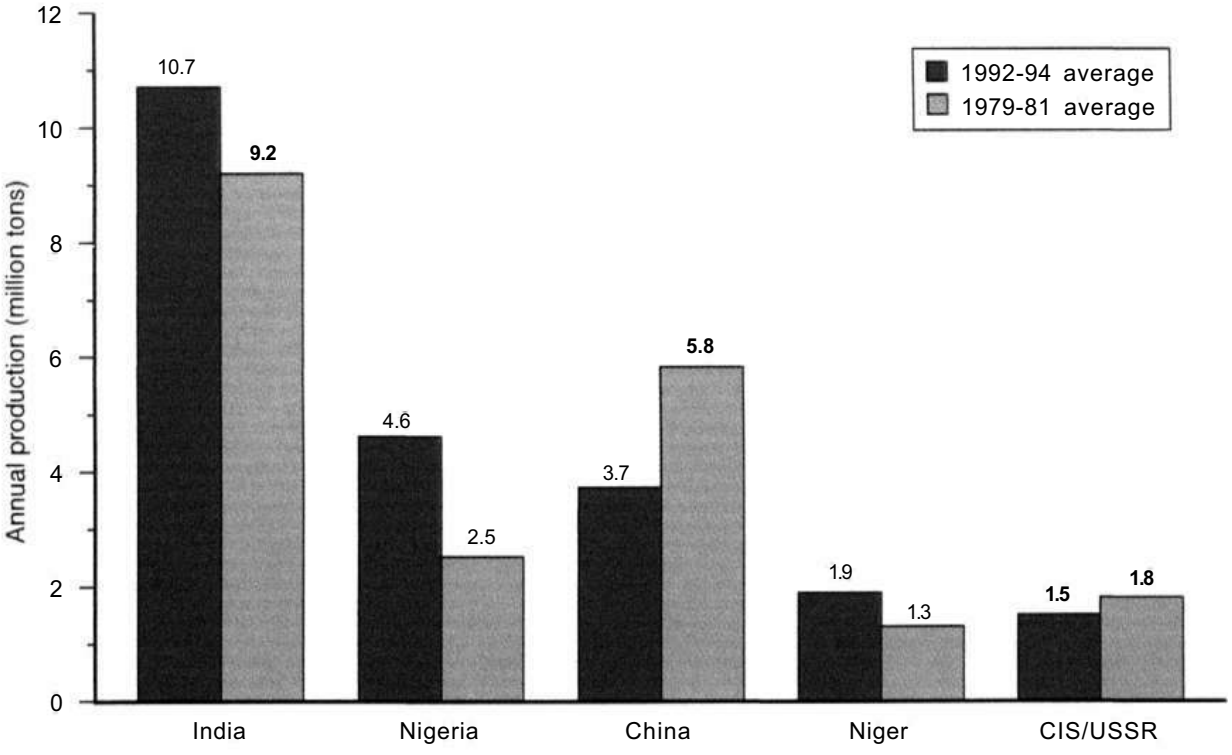


Figure 1. The worlds major millet producers.

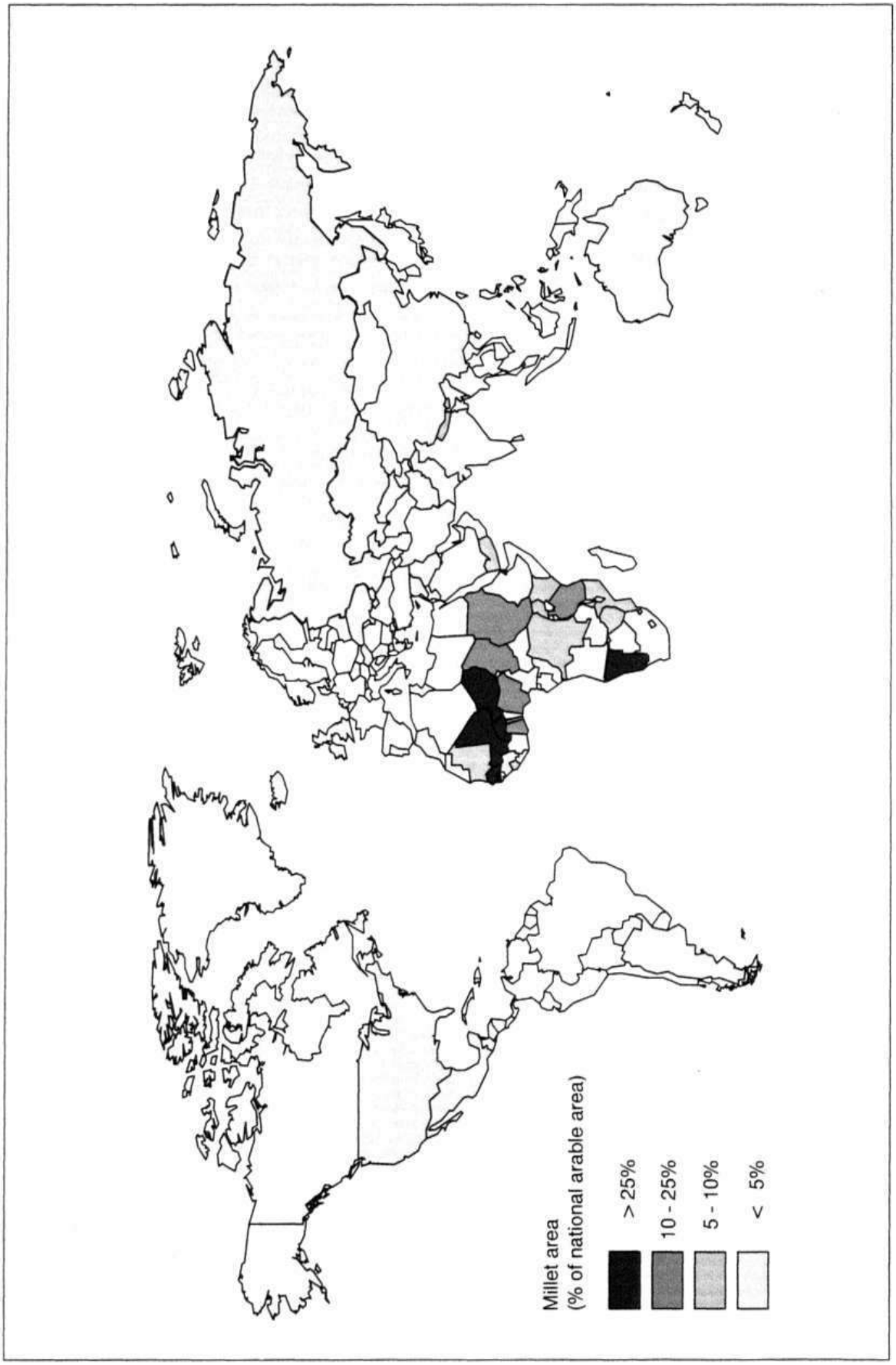


Figure 2. Relative importance of millet worldwide.

forms of this "ditch millet" are only found in Asia. In Latin America, millet production is confined to a small area in Argentina.

Among the developed countries, millet cultivation (almost entirely proso millet) is concentrated in the CIS, particularly in the Russian Federation, Kazhakastan and the Ukraine. Production in North America, Australia and Europe is extremely limited. In some countries, millet is sown as a catch crop when sowing conditions for the main crop are unfavourable. However, even in such situations the grain is sometimes left unharvested and the area simply grazed by livestock.

Production Trends

Worldwide, the area sown to millet has remained relatively stable at around 38 million hectares for the past two decades (Table 1). Both production and yield increased by a little over 10 percent through the 1980s, but have remained unchanged since then. Current global production is about 28 million tons, and average yields are 0.75 t/ha. At a regional level, however, there are sharp differences in trends, especially between the two main producers, Asia and Africa (Fig. 3, 4 and 5).

Developing countries

In *Asia,* millet area declined by 2.4 percent per annum between 1979 and 1994, falling from 23 million to 17 million hectares (Tables 1 and 2). However, part of this decline was compensated by yield increases (1.5 percent per annum). During the past three decades, yields have roughly doubled in China - where they are now among the highest in the world - and increased by more than half in India. This progress is essentially a result of successful breeding research and the widespread dissemination of pearl millet hybrids in India and improved open-pollinated foxtail millet varieties in China.

Output trends in Asia have been heavily influenced by policy changes in China. The millet economy, which was earlier subjected to production quotas and farm and consumer prices set by the government, was virtually fully liberalized by 1987. This allowed farmers to shift to more remunerative crops, and respond to changing consumer preferences. Consequently, the millet area declined from 2.3 million hectares in 1989-91 to 1.9 million hectares in 1992-94, and current production is about half the peak levels reached in the mid 1980s. In fact, the government has discontinued millet procurement as a result of this decline.

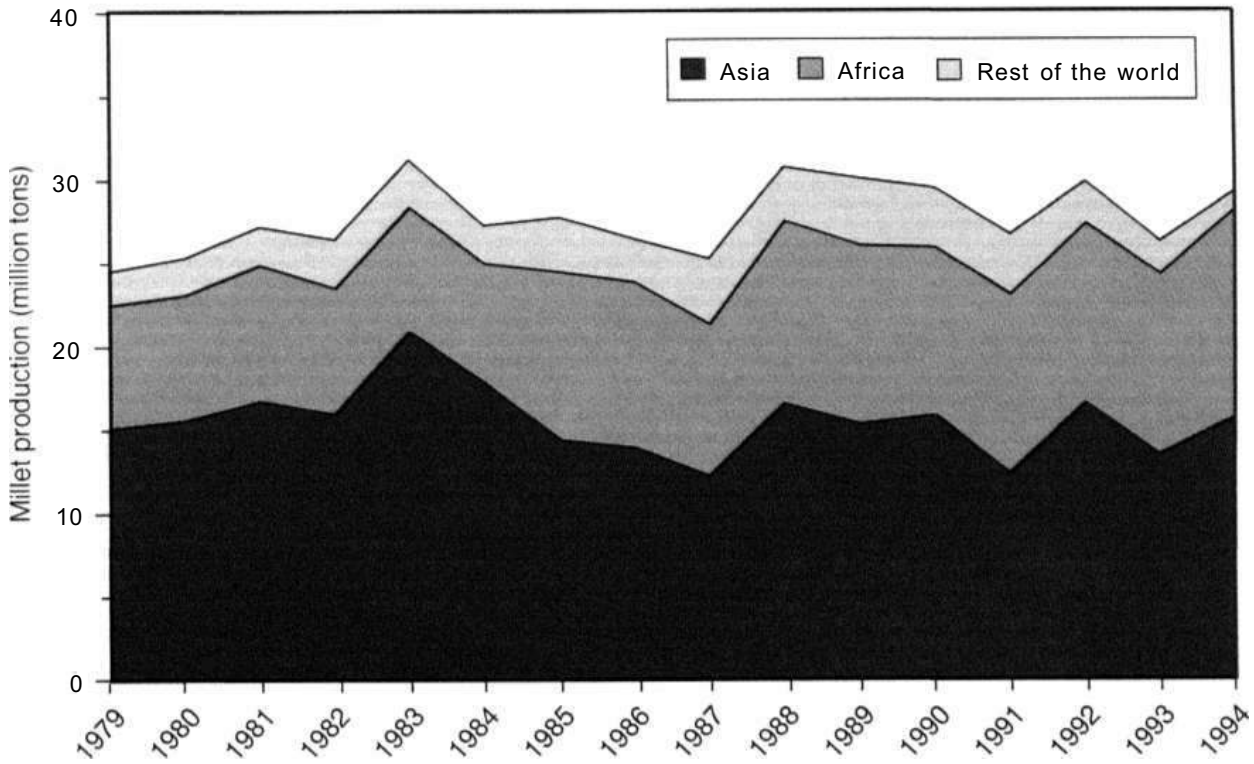


Figure 3. Global trends in millet production, 1979-94.

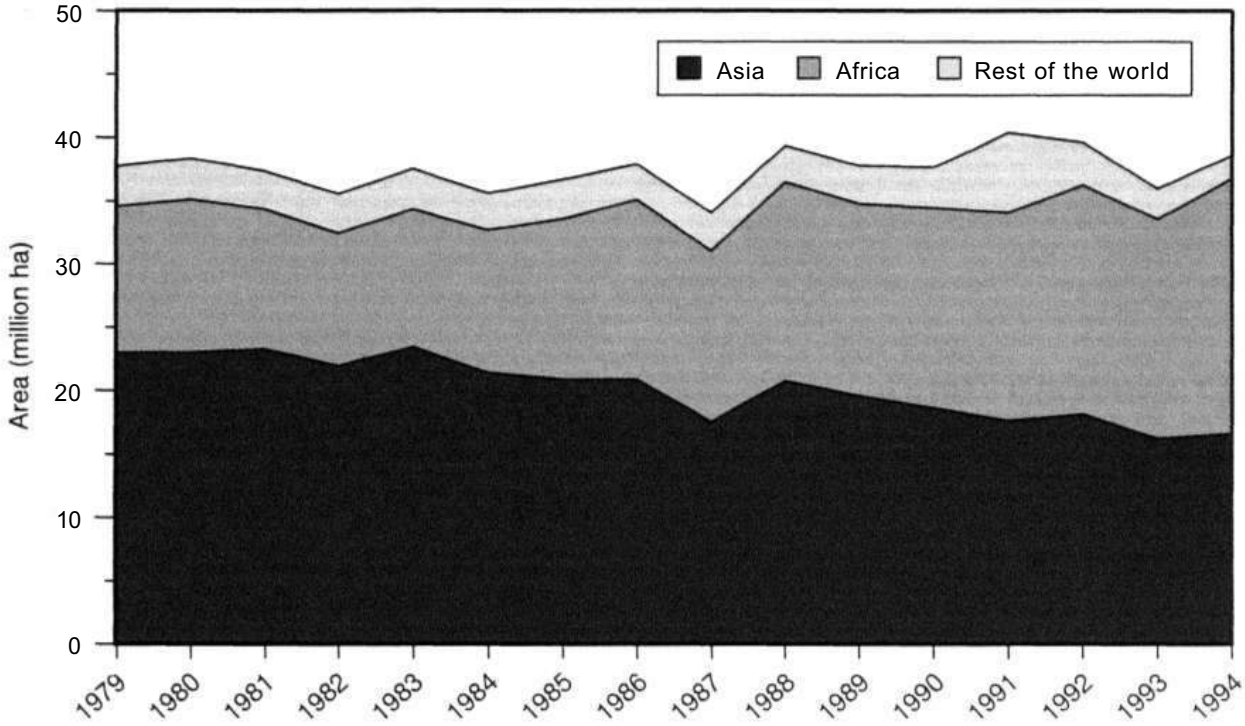


Figure 4. Global trends in millet area, 1979-94.

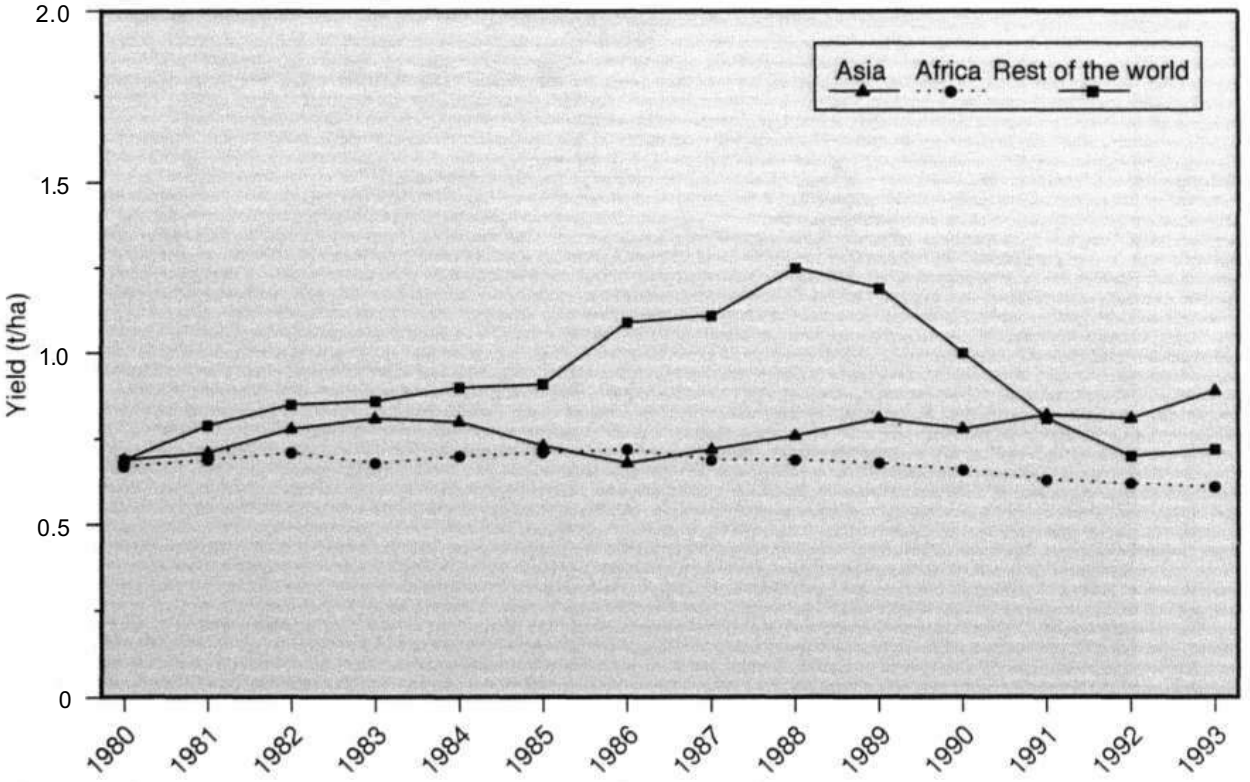


Figure 5. Global trends in millet yield, 1979-94 (3-year moving average).

Table 2. Millet annual growth rates, 1979-94.

	Area (%/yr)	Yield (%/yr)	Production (%/yr)	Per caput production (%/yr)
Developing countries	**0.3**	**0.4**	**0.6**	**-1.4**
Africa	4.1	-0.6	3.4	0.6
Northern Africa	2.7	-2.7	-0.1	-2.6
Sudan	2.7	-2.7	-0.2	-2.5
Western Africa	4.7	-0.4	4.2	1.2
Burkina Faso	3.8	2.0	5.9	3.0
Ghana	0.7	3.0	3.7	0.4
Cote d'Ivoire	2.6	2.5	5.2	1.3
Mali	5.1	-1.0	4.0	2.3
Niger	3.9	-1.0	2.8	-1.3
Nigeria	7.7	-2.3	5.2	2.2
Senegal	0.1	1.4	1.5	-1.4
Togo	3.5	-1.5	1.9	-1.2
Central Africa	3.6	-1.3	2.3	0.0
Cameroon	-6.1	3.3	-3.0	-5.8
Chad	5.4	-0.5	4.8	2.0
Eastern Africa	0.5	-0.1	0.4	-2.4
Ethiopia	1.1	0.8	1.8	-1.0
Kenya	3.7	-2.4	1.2	-2.3
Tanzania	-2.0	-2.4	-4.4	-7.3
Uganda	2.3	0.5	2.8	-0.5
Zimbabwe	-1.6	-2.6	-4.2	-7.2
Southern Africa	5.9	-4.5	1.1	-1.8
Asia	-2.4	1.5	-0.9	-2.8
Near East	-2.0	-3.1	-5.0	-7.7
Far East	-2.4	1.5	-0.9	-2.7
China	-6.1	1.8	-4.5	-5.8
India	-1.8	2.7	0.9	-1.2
Myanmar	0.5	1.5	2.0	-0.2
Nepal	4.6	1.5	6.2	3.5
Pakistan	-1.8	-1.2	-3.0	-6.3
Central America and the Caribbean	0.0	0.0	0.0	0.0
South America	-12.5	2.3	-10.5	-12.2
Argentina	-12.5	2.3	-10.5	-11.8
Developed countries	**-0.3**	**0.4**	**0.1**	**-0.9**
Australia	0.6	-0.5	0.2	-1.3
United States	4.3	-0.1	4.3	3.3
CIS[1]	-0.6	0.2	-0.3	-2.0
World	**0.3**	**0.4**	**0.7**	**-1.1**

1. Until 1991, area of the former USSR.

Source: FAO

Africa is the only region where millet production is growing, having risen from 8 million to over 11 million tons between 1979-81 and 1992-94 (Table 1). Most of the increase in production, however, occurred during the first half of the 1980s and has since been sustained by area expansion, mainly in the Sahel and to a smaller extent in other countries.

For many African countries, millet yields have remained stagnant or fallen (Tables 1 and 2), partly because much of the expansion has been into areas with poor soils and low, erratic rainfall. Overall, millet production has grown slightly faster than population with per caput production increasing by 0.6 percent per annum between 1979 and 1994. However, this situation is likely to be reversed in the near future.

In a number of countries, consumption levels of millet have been maintained only through area expansion. Even so, most millet production areas remain food-insecure. As land constraints become more severe, it is imperative that productivity of this key staple is increased to ensure at least minimal food security.

Developed countries

The only millet producer of any significance in the developed countries is the CIS (Table 1). Millet production rose sharply during the 1980s as a result of large increases in productivity (from 0.63 to 0.86 t/ha between 1979-81 and 1989-91). However, subsequent developments were similar to those in China.

In the Russian Federation, for example, production levels were supported by prices unrelated to production costs and determined by production quotas set by the government. When price setting was discontinued and quotas abolished, the market collapsed. Land was shifted from millet to wheat and other grains. Millet output dropped from 2.3 million tons in 1989 to 482,000 tons in 1994.

Kazhakastan traditionally produced millet mainly for export to other parts of the former USSR. When this trade disappeared during the early 1990s, following declining demand, production fell from 1.0 million tons to 300,000 tons per annum.

Production constraints

Millet production in the developing world, particularly in Africa, suffers from a number of constraints - poor soil fertility, low and erratic rainfall, high temperatures, widespread *Striga* infestation, downy mildew disease and loss of grain to birds.

Population pressures have led to a shortening of fallow periods, which in turn has accelerated the decline in soil fertility. These processes have also prompted the expansion of millet into more marginal lands. The impact is evident in the declining yields of millet in the major producing countries in Africa (Niger, Mali, Nigeria) over the past 15 years. Similar trends are also evident in the harsher millet production environments in Asia (e.g., western Rajasthan in India).

In addition, millets are cultivated on small, fragmented production units and are often intercropped (usually with legumes and sometimes with sorghum or maize).

Unreliable precipitation tends to keep the use of inputs such as chemical fertilizer, pesticides and hired labour to a minimum; and limited commercial demand depresses the incentive to use purchased inputs.

Crop improvement is generally more difficult in millet than in most other crops, largely because of the nature of the environment in which they are grown (see section on Technological Change). National millet improvement programmes began much later and remained weaker than those for many other crops.

Budgets for millet breeding research are low in most countries. Moreover, almost no experience has been acquired on millet breeding in developed countries that could be transferred to developing countries, as has been done for wheat and maize. Among the different types of millet only pearl millet, and to a small extent finger millet, has so far been researched at the international level. Where new technologies for crop and resource management have been developed, adoption has been poor, partly because of inadequate extension, but, equally, because farmers in harsh environments are generally more risk-averse than their counterparts in more favourable environments. The returns from investing labour and capital in millet production may be lower than the gains derivable from such investments in other farm and non-farm enterprises. Further, many new technologies may not be properly tailored to farmers' severely resource-constrained circumstances.

Varietal improvement

Hybrid breeding programmes have traditionally targeted the relatively better environments, although even these environments are harsher than those for most other crops. Hybrid grain cultivars have been developed for pearl millet in India and the United

States, but perform best in areas where rainfall is reliable. In drier areas with more erratic rainfall, it is far more difficult and time-consuming for breeders to identify dual-purpose grain/stover combinations that are superior across a range of growing conditions. For these areas, crop breeders have concentrated on developing open-pollinated varieties that give stable grain and straw yields and suit the prevailing rainfall pattern, rather than on attempting to maximize yield potential under more favourable conditions.

Grain yields of improved cultivars grown with low to moderate inputs can exceed those of local landraces by about 20 percent; an even more important advantage is that they often mature earlier, and thus perform better under terminal drought stress. However, the adoption of improved varieties remains poor outside a few countries, such as China (foxtail millet), the CIS (proso millet), India (pearl millet) and the United' States (proso, foxtail and pearl millets). For example, in Niger, the world's fourth largest producer, improved varieties account for only 5 percent of the millet area, in part because the seed multiplication and distribution system is inadequate.

Utilization

Although millet represents less than 2 percent of world cereal utilization, it is an important staple in a large number of countries in the semi-arid tropics, where low precipitation and poor soils limit the cultivation of other major food crops.

Millet utilization is mostly confined to the developing countries, even more so after production and utilization fell sharply in the CIS, the largest producer in the developed world. Accurate data are not available for most countries, but it is estimated that about 80 percent of the world's millet (and over 95 percent in Asia and Africa) is used as food, the remainder being divided between feed (7 percent), other uses (seed, beer, etc.,) and waste (Table 3).

Table 3. Millet utilization by type, region and selected countries, 1992-94 average.

	Direct food ('000 tons)	Feed ('000 tons)	Other uses[1] ('000 tons)	Total ('000 tons)	Per caput food use (kg/yr)
Developing countries	**21776**	**966**	**3767**	**26509**	**5.08**
Africa	8673	187	2328	11188	13.40
Burkina Faso	683	2	126	811	68.52
Chad	217	0	41	258	33.73
Ethiopia	108	0	153	260	1.97
Mali	658	3	119	781	74.63
Niger	1440	17	259	1716	162.45
Nigeria	3315	100	1155	4570	31.50
Senegal	505	5	83	593	61.61
Sudan	364	20	76	460	14.14
Tanzania	177	2	53	233	6.41
Uganda	517	20	95	633	25.93
Asia	13103	748	1433	15284	4.17
China	3277	327	257	3861	2.74
India	9216	283	1100	10599	10.23
Central America and the Caribbean	0	0	0	0	0.00
South America	0	31	6	37	0.00
Developed countries	**513**	**970**	**323**	**1805**	**0.40**
North America	0	180	0	180	0.00
Europe	0	4	1	5	0.00
CIS	504	736	316	1555	1.73
Oceania	0	1	0	1	0.00
World	**22289**	**1936**	**4090**	**28314**	**4.00**

1. For seed, manufacturing purposes and waste.

Source: FAO

Food use

Per caput food consumption of millet varies greatly between countries; it is highest in Africa, where millet is a key food staple in the drier regions. Millet represents about 75 percent of total cereal food consumption in Niger and over 30 percent in most other countries in the Sahel. It is also important in Namibia (25 percent of total cereal food consumption) and Uganda (20 percent).

Outside Africa, millet food consumption is important in parts of India, China and Myanmar. Utilization is negligible in Latin America, the Caribbean and all the developed countries. The exception was the former USSR until the late 1980s. However, under the economic transition process and the removal of price subsidies, utilization in the USSR/CIS fell sharply.

Millet is a high-energy, nutritious food, especially recommended for children, convalescents and the elderly. Several food preparations are made from millet, which differ between countries and even between different parts of a country. These consist primarily of porridge or pancake-like flat bread. However, because wholemeal quickly goes rancid, millet flour (prepared by pounding or milling) can be stored only for short periods.

Millet is traditionally pounded in a mortar, but mechanical dehulling and milling are increasingly used since they eliminate a considerable amount of hard labour and generally improve the quality of the flour.

Worldwide, millet food consumption has grown only marginally over the past 30 years, while total food use of all cereals has almost doubled. Millet is nutritionally equivalent or superior to other cereals[2]. However, consumer demand has fallen because of a number of factors, including changing preferences in favour of wheat and rice (cheap imports are available in several countries), irregular supplies of millet, rising incomes and rapid urbanization. Particularly in urban environments, the opportunity cost of women's time has encouraged the shift from millet to readily available processed foods (milled rice, wheat flour, etc.,) that are far quicker and more convenient to prepare.

2. Protein contents in pearl, proso and foxtail millets are comparable with those in wheat, barley and maize. Finger millet has a slightly lower protein content, but is in fact nutritionally superior because the protein quality is generally as good or better than in other cereals. Finger millet is also high in calcium and iron, and contains fairly high levels of methionine, a major limiting amino acid in many tropical cereals.

Animal feed

Utilization of millet grain as animal feed is not significant. It is estimated that less than 2 million tons, (about 7 percent of total utilization), is fed to animals, compared with about 30 million tons of sorghum (almost half of total output). In the developing countries, use of millet grain for animal feed is concentrated in Asia; very little is fed in Africa. However, millet fodder and stover are a valuable and critical resource in the crop/livestock systems where millet is grown.

Feed use estimates are heavily influenced by assumptions made for China, the world's third largest producer. In fact, little reliable information is available on feed use in this country. Based on very rough calculations of feed use in the CIS, it is estimated that about 1.0 million tons per annum are currently used as animal feed in the developed countries (Table 3). Western Europe, North America and Japan together use slightly over 200,000 tons, almost exclusively as bird seed. Recent increases in the use of pearl millet as a lower-cost substitute for maize feed in aquaculture and dairy and poultry farming in India and the southeastern United States are not well documented, and, in any case, at the moment represent only a small fraction of overall feed grain utilization.

Feeding trials have shown that pearl millet grain compares favourably with maize and sorghum as a high-energy, high-protein ingredient in feed for poultry, pigs, cattle and sheep. Nevertheless, very little millet is used as feed. First, as millet is grown mostly on marginal lands and production is barely sufficient to satisfy food requirements, little surplus is left for animal feed. Second, millet production fluctuates widely from year to year because of rainfall variability and drought in the main production areas. This deters a closer integration of millet production with intensive livestock operations. Third, millet yields are generally lower than those of other crops produced commercially in more favourable environments. Thus, production and transport costs are often prohibitive compared to alternative ingredients of compound feeds.

Other uses

There are few other uses of millet. Small quantities of finger millet are used in Zimbabwe for commercial brewing and opaque beer. Food technologists have experimented with the incorporation of pearl millet into composite flour, but the commercial application of this technology is limited.

International Trade, Market Prices and Stocks

Global trade in millet is estimated to range between 200,000 and 300,000 tons (Table 4a and b), representing roughly 0.1 percent of world trade in cereals or 1.0 percent of world millet production. The major exporters are India, the United States, Argentina and China, which together supply about two-thirds of recorded exports. A sizeable proportion (about 100,000 tons) of the recorded international trade is in proso millet, exported by the United States, Argentina and Australia to other developed countries. Another 60,000 tons are pearl millet exports by India. In recent years, China has started to export some quantities of foxtail millet.

The European Community[3], accounts for more than 50 percent of global imports. During the 1992-94 period, the EC purchased an average of 145,000 tons per year (Table 4b). Other major, regular importers are Japan, Switzerland and Canada. In contrast, countries like Kenya, Mauritania, Nigeria, Tanzania, and Uganda no longer import millet, at least officially.

Besides this official trade, a substantial unrecorded quantity of millet is traded within subregions in Africa, with grain moving from surplus to deficit areas. In Western Africa, for example, there is movement of millet during good years from surplus producing areas along the southern boundary of the Sahara both southward to higher-rainfall but millet-deficient areas and northward to supply nomadic populations.

The magnitude of officially recorded trade has marginally declined over the past 20-30 years, and there has been a slight change in direction. Imports by developed countries have tended to decrease over the past two decades, while those by the developing countries remained steady through the 1960s, rose during the 1970s, but fell thereafter, having been replaced by rising imports of wheat and rice. Developed countries now account for an estimated 70 percent of recorded world imports, compared with about 50 percent during the early 1960s.

3. Under the Lome IV Agreement, ACP countries (Africa, Caribbean, Pacific) can export up to 60,000 tons per year to the EC without import levies.

Table 4a. Millet recorded international trade: exports[1].

Exports	1979-81 ('000 tons)	1989-91 ('000 tons)	1992-94 ('000 tons)
Africa	57.9	26.4	20.2
Mali	0.0[2]	15.0	18.0
Niger	36.7	0.1	0.0
Sudan	2.1	1.3	0.0
Asia	12.0	16.8	84.6
China	8.7	4.6	21.6
India	0.0	7.0	58.5
North, Central and South America, and the Carribean	145.9	119.1	90.3
Argentina	112.9	41.0	42.9
United States	33.0	75.5	45.5
Europe	20.5	33.0	43.7
EC (12 countries)[3]	15.6	22.6	28.3
Hungary	4.4	6.9	13.0
Oceania	14.6	13.6	16.3
Australia	14.6	13.6	16.3
World	**250.9**	**208.7**	**255.0**
Developing countries	**181.9**	**84.0**	**147.4**
Developed countries	**69.0**	**124.7**	**107.6**

1. Each figure is a 3-year average for the respective period, e.g., 1979-81. Source: FAO
2. Shown as zero for trade less than 50 tons.
3. Including intra-trade among member countries.

Table 4b. Millet recorded international trade: imports[1].

Imports	1979-81 ('000 tons)	1989-91 ('000 tons)	1992-94 ('000 tons)
Africa	82.0	7.9	40.9
Angola	0.0[2]	0.0	21.7
Cote d'Ivoire	0.0	2.6	1.2
Gabon	0.0	0.0	0.1
Mauritania	1.0	0.0	0.0
Mali	40.0	0.0	0.5
Niger	8.0	2.4	0.5
Nigeria	26.7	0.5	0.0
Senegal	0.0	2.1	15.0
Sudan	0.0	0.0	0.3
Zimbabwe	0.2	0.0	0.3
Asia	58.9	40.3	44.3
Japan	53.1	23.7	20.3
Kuwait	1.1	0.3	0.5
Malaysia	0.7	2.1	2.4
Saudi Arabia	1.4	1.5	2.8
Singapore	0.4	1.1	0.7
Thailand	0.8	1.7	1.8
North, Central and South America and the Caribbean	4.0	26.2	18.1
Brazil	3.8	3.7	5.8
Canada	0.0	5.9	8.2
Europe	145.7	145.5	155.4
Austria	2.3	1.2	0.8
EC (12 countries)[3]	114.9	131.5	145.2
Switzerland	26.0	9.2	8.2
Oceania	0.8	0.8	5.7
World	**291.4**	**220.8**	**264.3**
Developing countries	**90.5**	**43.8**	**75.4**
Developed countries	**201.0**	**177.0**	**188.8**

1. Each figure is a 3-year average for the respective period, e.g., 1979-81. Source: FAO
2. Shown as zero for trade less than 50 tons.
3. Including intra-trade among member countries.

Note: The discrepancies between imports and exports are largely because some exporting countries do not report millet sales at all, or include them under "other cereals".

International trade in millet is controlled by a few specialized trading companies and generally conducted on a sample basis. Only Argentina is reported to have established official export quality standards. International prices are highly volatile, determined largely by supply volumes, and are usually unrelated to those of other major coarse grains such as maize, sorghum or barley. Quotations[4] are not regularly published or recorded according to official statistics. Table 5 therefore compares export prices for millet in Argentina, Australia and the United States. The high degree of price variability among suppliers, even in the same year, is due to the "thin" market, with small trade volumes and very few buyers and sellers.

Since millet yields in the major exporting countries are substantially lower than for other cereals, and taking into consideration the opportunity cost of growing millet rather than other crops, prices have to be considerably higher to make cultivation remunerative. As a result, prices are generally higher than those of other grains, except in India, where millet and sorghum prices are roughly equal. These prices

4. International quotations are published in the Public Ledger, London, for UK imports and in STAT (Stat Publishing, Blaine, WA 98230, BC, Canada) for Argentine and US exports.

Table 5. Average annual export prices for millet.

Year	Argentina (US$/ton)	United States (US$/ton)	Australia (US$/ton)
1979-81 average	129	186	224
1983	147	175	251
1984	166	176	254
1985	107	171	210
1986	139	151	195
1987	108	154	162
1988	123	173	110
1989	190	177	249
1990	143	188	318
1991	107	156	249
1992	114	170	249
1993	156	223	245
1994	228	254	325

Source: FAO

discourage the use of millet in compound feed. Only on rare occasions when prices are extremely low is millet used as a substitute for sorghum or maize in feed formulations.

World millet stocks, currently estimated at 3.0 million tons, are relatively unimportant in the global cereal context. They represent only 1.0 percent of world cereal carryover stocks. Most non-commerical stocks are held by farmers (but not officially recorded) in developing countries for household consumption, seed and limited trading on local markets. Such stocks, while critical in terms of food security at household or local level, are not significant in terms of global trade.

Most millets have excellent storage properties and can be kept for up to 4-5 years even in simple storage facilities, such as traditional granaries. This is because the seeds are protected from insect attack by the hard hull covering the endosperm, and because grain is usually harvested and stored in dry weather conditions. Thus, although there may be large year-to-year variations in production, stocks can easily be built up after favourable years.

Internal Marketing and Domestic Policies

Millet marketing channels in many developing countries are not well developed. There are three main reasons: scattered and irregular supplies, large distances between producing areas and the main urban centres and limited demand in urban areas. Only 15-20 percent of the pearl millet produced in India, and perhaps 5-10 percent in Africa, enters the commercial marketing system. Moreover, although a number of developing countries have market intervention regulations to stabilize domestic millet prices, these regulations are effectively enforced in only a few countries. In several cases, the large year-to-year variations in the size of the harvest make it difficult for governments to provide adequate farm income support and simultaneously maintain adequate stocks in anticipation of lean years. Also, many governments do not include millet in their farm price-support programmes.

Technological Change, Environmental Issues and Focus of Research

Research has generally focused on pearl millet, the most important species. Adaptation is a more serious problem in millet than in many other crops. Pearl millet originated in Western Africa, evolving in a harsh environment in association with a number of diseases and insect pests. Local landraces developed through natural and human selection gave poor yields, but showed reasonable tolerance to many of these hazards. Improved varieties introduced from Asia, Eastern Africa or the United States, where these problems are less prevalent, have generally failed to show any superiority over local varieties in Western Africa. Indeed, these introduced materials

generally have serious adaptation problems, because of lack of tolerance to high soil temperatures and sandstorms as seedlings, and greater susceptibility than local landraces to diseases and insect pests.

Breeding for drought tolerance, a major problem in all millet environments, is also difficult because it is hard to accurately simulate drought conditions and because manipulating a plant trait to improve tolerance to severe drought stress at one growth stage may result in increased sensitivity to drought at another stage.

These difficulties notwithstanding, national and international research programmes have made significant advances. Improvements in pearl millet yields in the developing countries, mainly in India, have occurred largely due to the development, release and widespread multiplication of improved open-pollinated and hybrid cultivars. Because of their low sowing rates (3-4 kg/ha of seed) and high multiplication rates (200 to 500-fold per generation), these improved cultivars have been adopted fairly widely even by subsistence farmers in specific, relatively favourable, millet environments, e.g., Gujarat, Haryana and Maharashtra in India.

In Africa, hybrids have yet to make a significant impact because extension is inadequate and the seed industry poorly developed. However, there has been some adoption of improved open-pollinated varieties in Southern Africa. These offer marginal gains in grain yield over traditional landraces, and are less prone to end-of-season drought because they mature earlier, thus reducing the risk of crop failure.

The problem of environmental degradation is common for many crops, but particularly serious in millet. Population growth has forced farmers to shorten fallow periods (which in turn has resulted in declining soil fertility) and to expand millet cultivation into more marginal lands. This is most evident in Africa, where millet area has increased and yields have declined over the past 15 years. This problem is less serious in Asia; however, in the harsher environments in Rajasthan, the expansion into more marginal areas will make future productivity increases harder to achieve.

Improving the reliability of grain and stover yields continues to be the major focus of millet research. Current millet research is moving in two broad directions:

- shorter crop life cycles of 70-80 days (as against the more usual 90 days), so that the plant can escape end-of-season drought;
- better tolerance to mid-season drought.

Crop improvement programmes are now integrating farmers more closely than before into the breeding and diffusion process in order to develop technologies that are more accurately targeted at farmers' constraints, and, therefore, more likely to be adopted. The emphasis is on breeding cultivars with durable resistance to downy mildew and foliar diseases. Other important research objectives are to:

- identify *Striga* resistance sources and develop better crop management technologies to reduce losses due to *Striga,* particularly in Western Africa;
- develop integrated pest management strategies to reduce losses due to the millet stem borer.

Medium-term Outlook[5]

World millet production is projected to increase from 28 million tons (1992-94 average) to about 33 million tons in the year 2005 (Tables 6 and 7). Most of the growth will be in the developing countries, where production is projected to grow at 1.4 percent per annum from 27 million tons in 1992-94 to 31 million tons in the year 2005. Africa is expected to show the highest growth rates (2.4 percent per annum) and the largest absolute increase in production.

At the global level, growth will come mainly from yield increases (Table 7). In Africa, both area expansion (1.1 percent per annum) and yield increases (1.4 percent) will contribute. However, growth in output will remain slower than population growth, and per caput consumption in Africa will decline. In Asia, production is projected to increase marginally from 15 million tons in 1992-94 to 16 million tons in 2005. The increase will come mainly from higher productivity - yields are expected to grow from 0.9 t/ha in 1992-94 to about 1.1 t/ha in 2005. Most of the production growth is expected to occur in India. In China, millet yields are already among the highest in the world and will increase still further, especially if millet hybrids, which are still not widely used, are developed and disseminated. However, overall output is likely to fall because land-use patterns are changing in favour of other agricultural products and economic activities.

5. Covers the period from 1992-94 to 2005. The supply outlook is based on estimates of future area and yields projected from recent trends, with some adjustments based on judgement of how individual countries are likely to perform, assuming no major policy changes. Demand projections are based on United Nations population projections and World Bank income growth rates.

Table 6. Projected millet production, demand and trade ('000 tons), 1992-94 to 2005.

	Actual (1992-94 average)					Projected (2005)				
	Production	Total use	Food use	Feed use	Trade gap[1]	Production	Total use	Food use	Feed use	Trade gap[1]
Developing countries	**26,592**	**26,509**	**21,776**	**966**	**83**	**31,394**	**31,421**	**25,510**	**1,542**	**-27**
Africa	11,358	11,188	8,673	187	170	15,072	15,138	11,705	438	-66
Northern Africa	554	467	365	26	87	765	738	499	136	27
Western Africa	8,986	8,921	6,987	129	65	12,024	12,051	9,430	243	-27
Central Africa	447	435	356	4	12	505	502	437	10	3
Eastern Africa	1,332	1,326	929	29	6	1,740	1,792	1,289	49	-52
Southern Africa	39	39	35	0	0	39	55	50	0	-16
Asia	15,171	15,284	13,103	748	-113	16,229	16,235	13,805	1,104	-6
Near East	117	118	75	30	-1	148	145	79	49	3
Far East	15,054	15,166	13,028	718	-112	16,081	16,090	13,726	1,055	-9
South America	63	37	0	31	26	92	46	0	39	46
Developed countries	1,786	1,806	513	970	-20	1,662	1,595	488	1,009	67
World	**28,378**	**28,314**	**22,289**	**1,936**	**64**	**33,056**	**33,016**	**25,998**	**2,591**	**40**

1. Production minus utilization. Source: FAO/ICRISAT

Food demand

Millet will continue to be used primarily for human food, and will remain a major source of calories and a vital component of food security in semi-arid areas in the developing world. With the exception of the CIS, food use will remain confined to the developing countries, which currently account for 98 percent of total food use. Food demand for millet in these countries is expected to grow at 1.3 percent per annum between 1992-94 and 2005, with important differences in growth patterns between Asia and Africa. Asia now accounts for 59 percent of total millet food use and Africa for 39 percent. By the year 2005, however, Asia's share will fall to 53 percent while Africa's will rise to 45 percent (Table 6).

In Asia, food use is projected to grow by only 0.4 percent per annum (Table 7), as consumers shift to other foods. Growth will be stronger in Africa (2.6 percent per annum), but will be constrained by supply rather than demand factors. As per caput consumption falls, calories for African households will have to be provided increasingly by imports or by food grains produced in higher potential areas within each country.

One major concern is the likelihood of growing millet deficits, particularly in Africa. By 2005, the projected millet deficits for Africa will be 66,000 tons per year, as against a current "surplus" of 170,000 tons (Table 6). Some of this deficit could be covered by imports or food aid. However, falling per caput production could have serious consequences for food security and nutrition in a region that already experiences frequent food shortfalls. It should be noted that even this projection is based on a somewhat optimistic production growth rate of 2.4 percent per annum between now and 2005.

Feed demand

Global demand for millet as feed in 1992-94 was 1.9 million tons, projected to grow to about 2.6 million tons in 2005 (Table 6). Again, whether such growth will be achieved depends largely on the developing countries. Their feed use of millet is projected to increase by 60 percent by the year 2005, depending mainly on developments in India, Nigeria and Sudan. Feed use in China is expected to decline. The use of millet for bird seed in developed countries is unlikely to change significantly from the current level. These countries are expected to continue to use millet mainly as bird seed because it is too expensive to be competitive as an ingredient in livestock feed, except as a locally produced feed grain on light soils in parts of the Unites States.

Trade

Future world trade in millet is very difficult to project because of its small size, the unknown volume of unrecorded trade and uncertainties regarding both supply and demand. If larger surpluses of millet become available in some countries (for example, in Western Africa), trading opportunities in those regions would increase. However, in view of the huge distances and the high transport costs, and the large

Table 7. Millet projected growth rates, 1992-94 to 2005.

	Area (%/yr)	Yield (%/yr)	Production (%/yr)	Per caput production (%/yr)	Utilization		
					Total (%/yr)	Food (%/yr)	Feed (%/yr)
Developing countries	**0.2**	**1.2**	**1.4**	**-0.5**	**1.4**	**1.3**	**4.2**
Africa	1.1	1.2	2.4	-0.7	2.6	2.5	7.4
Northern Africa	0.9	1.8	2.7	0.4	3.9	2.6	14.8
Western Africa	1.1	1.4	2.5	-0.9	2.5	2.5	5.4
Central Africa	-0.1	1.1	1.0	-2.1	1.2	1.7	7.9
Eastern Africa	1.8	0.4	2.3	-1.0	2.5	2.8	4.5
Southern Africa	*6.6*	-6.1	0.5	-3.0	2.8	3.0	0.0
Asia	**-0.9**	**1.5**	**0.6**	**-1.1**	**0.5**	**0.4**	**3.3**
Near East	0.0	1.9	1.9	-0.7	1.7	0.4	4.2
Far East	-0.9	1.5	0.6	-1.0	0.5	0.4	3.3
South America	2.5	0.8	3.3	1.6	1.8	0.0	1.9
Developed countries	**-2.2**	**1.6**	**-0.6**	**-1.1**	**-1.0**	**-0.4**	**0.3**
World	**0.1**	**1.2**	**1.3**	**-0.3**	**1.3**	**1.3**	**2.5**

Source: FAO/ICRISAT

variability of tradeable volumes, any significant trade expansion is unlikely. Most international trade in millet up to the year 2005, therefore, is envisaged to remain largely restricted to border transactions among developing countries and limited but regular purchases by the developed countries as in the past.

Summary and Conclusions

Pearl millet is grown largely for its ability to produce grain under hot, dry conditions on infertile soils of low water-holding capacity, where other crops generally fail completely. Correspondingly, it is produced mainly in outlying areas peripheral to the major production and population centres of the developing world. Yields are low, averaging only three-quarters of sorghum yields in Africa and Asia. Most farmers who rely on this crop are quite poor and frequently experience food shortfalls. Little of the millet production enters the commercial market; most never leaves the farm on which it is grown. Rather, many millet farmers are more likely to be food buyers than sellers.

The combination of poverty and severe environmental conditions makes it difficult to improve productivity in pearl millet. While yields are growing in Asia, many African producers are unable to raise yields because of the continuing expansion into even drier and harsher agroecologies and poor adoption of "improved" technologies in these environments. A major reason for poor adoption is that some of these technologies are expensive or otherwise inappropriate for these harsh environments.

The growth of pearl millet yields in Asia is due to the adoption of improved cultivars (both hybrid and open-pollinated) and at least limited investments in fertility maintenance. Farmers are also expanding investments in water conservation technologies as land constraints become more severe. Yield improvements would be greater if the move to more remunerative oilseed crops (e.g., groundnut, sesame and castor) were not so prevalent in the more favourable pearl millet production areas in Asia.

In Africa, by contrast, most farmers continue to plant traditional landrace cultivars. While there are signs of interest in new open-pollinated cultivars, private seed companies do not believe this area is profitable, and public sector investments in seed production are limited. The widespread promotion of hybrids in Asia has encouraged private investment in seed production, but the prospects for hybrid adoption in Africa remain unknown. The costs of distributing hybrid seed are higher than in Asia (because population densities are lower), and the willingness of the often poorer African farmer to purchase hybrid seed remains untested. However, given the low seed requirement and the low production costs (because of high multiplication rates), even poor pearl millet producers in Africa, similar to their counterparts in Asia, may find it worthwhile to invest in improved seed, either hybrid or open-pollinated.

There are strong justifications for more government investment in millet seed production and distribution as a means of reducing the costs of relief during droughts. Care must be taken to ensure that certification regulations for improved seed are reasonable and enforceable. Previous experience has shown that unreasonably stringent regulations serve only to restrict competition in the seed industry, resulting in seed shortages and unnecessarily high seed prices.

Prospects for the adoption of improved management technologies in both Africa and Asia are limited, for several reasons. Firstly, the high variability in annual rainfall, especially in Africa, makes it difficult for farmers to judge potential investment returns. Secondly, labour constraints restrict the adoption of improved soil and water conservation systems as households send children to school and adults to urban areas in search of employment. And thirdly, farmers judge the returns to cash investment in inputs, such as fertilizer, against the gains obtained by saving to buy food or livestock or education for their children.

Such factors require scientists and extension workers to be more imaginative in developing technologies suited to these difficult production environments. Breeders need to consider more carefully the trade-offs that farmers calculate between grain and fodder, between yield and yield stability, and between input responsiveness and productivity under low-input conditions. Resource management scientists must assume that farmers' decisions will change depending on rainfall levels over the course of the season, and target narrow opportunities for even marginal improvements in water-use efficiency and soil fertility. These may include aiming for a small investment in chemical fertilizer to complement the use of manure, or a legume rotation rather than a short-run profit-maximizing investment entailing higher production risk.

The prospects for expanding commercial trade in Africa are limited. The biggest opportunity lies in the expansion of trade between surplus and deficit rural households. This is made difficult by the variability of year-to-year production and the long distances between households in areas of relatively low population density. Traders face difficulties in identifying surplus and deficit areas, and the costs of grain collection and transport are high. However, there may be scope for improvements in market information systems and investment incentives to encourage private investment in grain trade. These have proven beneficial in India where there is greater, but still limited, commercial trade in millet grain. These investments can be justified as a component of national and regional drought relief strategies. In areas where inter-seasonal and inter-annual millet prices are highly variable, drought relief programmes could also seek to strengthen household and village grain stocks, for which millet is well adapted.

Small quantities of millet grain are traded for use as flour and beer malt in both Africa and Asia. In Africa, low productivity and high transport costs will restrict this trade to a high-priced premium market. In Asia, higher productivity and lower marketing costs (associated with higher population densities and better market infrastructure) offer better prospects for expanding millet sales. However, it will still be difficult for millet to compete with other cereals grown on substantially more productive land in regions with higher rainfall. In areas where millet is competitive in terms of price and feed value, demand for millet grain for fish and poultry feed may grow. Pearl millet has the advantage of superior adaptation to high temperatures and infertile soils with low water-holding capacity. In specific areas where these constraints are important, millet grain will compete effectively as a livestock feed against other cereals that must be transported across long distances at considerable expense. Further, there will remain a market niche for millet trade as bird seed.

There are indications that pearl millet is becoming increasingly important as a forage crop and as a cover crop or mulch for intensive legumes production on tropical acid soils. Further, it appears that pearl millet will soon become a regionally important alternative feed grain in subtropical areas in several countries. However, these new uses are relatively minor compared to the importance of millets as food crops of the rural poor, primarily in the tropics.

In sum, millet will remain largely associated with the food security of drought-prone human populations. Productivity has lagged, particularly in Africa, because of the severity of this environment and the pressure of human population growth on traditional land-extensive fallow systems. Correspondingly, productivity improvements will contribute most directly to the alleviation of poverty and food insecurity. The prospects for the expansion of market flows are reasonable if targeted within food-deficit areas. However, the prospects for commercial trade are limited, except in small specialty markets for flour, malt, feed grain and bird seed.

Annex I: Types of Millet

The various millet species can be divided into two broad categories: pearl millet and "small" millets. The latter group, with the exception of proso millet, have smaller grains than pearl millet.

Pearl millet (*Pennisetum glaucum, P. typhoides, P. tyhpideum,* P. *americanum)* is the most widely grown of all millets. It is also known as bulrush millet, babala, bajra, cumbu, dukhn, gero, sajje, sanio or souna.

Pearl millet is a traditional crop in Western Africa, particularly in the Sahel; in Central, Eastern and Southern Africa; and in Asia, in India and Pakistan and along the southern coast of the Arabian peninsula.

Pearl millet has been recently introduced as a grain crop in the southeastern coastal plain of the United States, where it has been used as a summer forage. Pearl millet can be grown on poor, sandy soils in dry areas that are unsuitable for maize, sorghum or finger millet. It is a summer cereal grass with large stems, leaves and heads. It is more efficient in its utilization of moisture than sorghum or maize.

The grain grows on condensed panicles (spiked) 10 to 150 cm in length. Pearl millet has the highest yield potential of all millets under drought and heat stress.

Finger millet (*Eleusine coracana*), known as ragi in India, is another important staple food in Eastern Africa and in Asia (India, Nepal). It has a slightly higher water requirement than most other millets and is found in cooler, elevated regions up to 2000 metres above sea level. The plant carries several spikes or "fingers" at the top of the stem. The grain is small (1-2 mm in diameter).

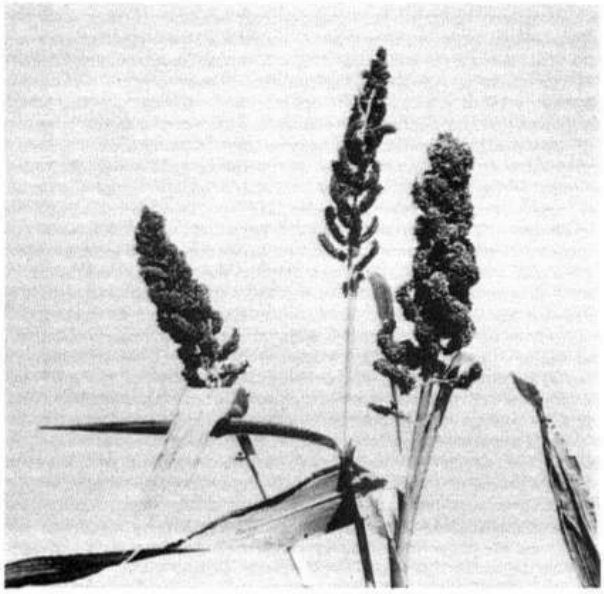
Proso or Common millet (*Panicum miliaceum*) is grown in temperate climates. It is widely cultivated in the Russian Federation, the Ukraine, Kazhakastan, the United States, Argentina and Australia. The plant has open, branching, drooping panicles and is tolerant of a wide range in temperature.

Foxtail millet (*Setaria italica*) is also adapted to moderate climates. It produces long, cylindrical or lobed, bristly, condensed panicles. China ranks first in the production of foxtail millet in the world. It is grown there for both food and feed. The crop is also grown in India, Indonesia, the Korean peninsula, and some parts of southern Europe. It is not grown to any extent in Africa outside the eastern highlands. Prior to the availability of sorghum-sudangrass forage hybrids, foxtail millet was an important temporary pasture species.

Teff (*Eragrostis tef*) is a very small-seeded grass that is cultivated for grain in the Ethiopian highlands, where its production exceeds that of most other cereals. It tolerates heavy soils with poor drainage characteristics. Several of its relatives are highly valued forage grasses in the world's arid zones.

White fonio (*Digitaria exilis*), Black fonio (*Digitaria iburua*), and Guinea millet (*Brachiaria deflexa*) are minor cereals of dry areas in sub-Sahelian Western Africa, White fonio is cultivated throughout much of this region, except Liberia. It is a very important crop in southern Mali, northeastern Nigeria, extreme southern Niger, western Burkina Faso, eastern Senegal and northern Guinea. Black fonio is found in isolated pockets in the Jos-Bauchi plateau of Nigeria and the northern parts of Togo and Benin. Guinea millet cultivation is confined to the Fouta-Djallon plateau of Guinea and Sierra Leone.

There are several other "minor" millets, some of which are of regional importance.



Barnyard millet (*Echinochloa crusgalli, E. colona*) is important in the tropics and subtropics of India.

Little millet (*Panicum sumatrense*) is widely grown in India, Nepal, Pakistan, Sri Lanka, eastern Indonesia and western Myanmar.

Kodo millet (*Paspalum scrobiculatum*) is harvested as a wild cereal in Western Africa and India, where it grows abundantly along paths, ditches and low spots. The species was domesticated in India about 3000 years ago.

Job's tears (*Coix lachrymal obi*) is a minor cereal even among the small millets, with production confined largely to Southeast Asia.

Annex II. Relative importance of millet species, 1992-94.

	Total millets ('000 tons)	Pearl millet (%)	Finger millet (%)	Proso millet (%)	Foxtail millet (%)	Teff millet (%)	Fonio millet (%)	Other millets (%)
Developing countries	**26591**	**55**	**12**	**9**	**20**	**1**	**0**	**3**
Africa	11358	87	7	0	0	1	0	5
Northern Africa	554	98	2	0	0	0	0	0
Libya	2	100	0	0	0	0	0	0
Morocco	5	100	0	0	0	0	0	0
Sudan	547	82	18	0	0	0	0	0
Western Africa	8986	95	0	0	0	0	0	5
Benin	26	100	0	0	0	0	0	0
Burkina Faso	793	99	0	0	0	0	0	1
Cote d' I voire	71	85	0	0	0	0	0	15
Gambia	39	97	0	0	0	0	0	3
Ghana	166	100	0	0	0	0	0	0
Guinea	13	95	0	0	0	0	0	5
Guinea-Bissau	26	100	0	0	0	0	0	0
Mali	732	95	0	0	0	0	5	0
Mauritania	4	100	0	0	0	0	0	0
Niger	1858	100	0	0	0	0	0	0
Nigeria	4620	98	0	0	0	0	0	2
Senegal	549	100	0	0	0	0	0	0
Sierra Leone	24	100	0	0	0	0	0	0
Togo	64	100	0	0	0	0	0	0
Central Africa	447	87	13	0	0	0	0	o
Cameroon	55	100	0	0	0	0	0	0
Central African Republic	11	87	13	0	0	0	0	0
Chad	282	100	0	0	0	0	0	0
Zaire	32	67	33	0	0	0	0	0
Eastern Africa	1332	35	50	0	0	9	0	6
Burundi	12	0	100	0	0	0	0	0
Eritrea	14	66	17	0	0	17	0	0
Ethiopia	265	0	14	0	0	86	0	0
Kenya	57	55	45	0	0	0	0	0
Malawi	9	40	60	0	0	0	0	0
Mozambique	19	80	20	0	0	0	0	0
Rwanda	1	0	100	0	0	0	0	0
Tanzania	230	70	30	0	0	0	0	0
Uganda	634	6	94	0	0	0	0	0
Zambia	49	40	60	0	0	0	0	0
Zimbabwe	67	70	30	0	0	0	0	0
Southern Africa	39	100	0	0	0	0	0	0
Angola[1]		80	20	0	0	0	0	0
Botswana	2	100	0	0	0	0	0	0
Namibia	37	100	0	0	0	0	0	0
Asia	15171	34	16	14	33	0	0	3
Near East	117	60	31	2	5	0	0	2
Afghanistan	22	0	100	0	0	0	0	0
Iran, Islamic Republic of	11	0	100	0	0	0	0	0
Iraq	1	0	100	0	0	0	0	0

1. Data for Angola not included as the millet figures are combined with those of sorghum.

Continued

Annex II. Relative importance of millet species, 1992-94 (*continued*)

	Total millets ('000 tons)	Pearl millet (%)	Finger millet (%)	Proso millet (%)	Foxtail millet (%)	Teff millet (%)	Fonio millet (%)	Other millets (%)
Jordan	2	0	100	0	0	0	0	0
Saudi Arabia	11	100	0	0	0	0	0	0
Syria	7	100	0	0	0	0	0	0
Turkey	4	0	0	33	67	0	0	0
Yemen	60	100	0	0	0	0	0	0
Far East	15054	34	16	14	33	0	0	3
Bangladesh	64	90	10	0	0	0	0	0
China	3671	10	30	10	50	0	0	0
India	10703	58	27	5	5	0	0	4
Korea Rep.	2	0	0	0	100	0	0	0
Korea DPR	50	0	0	31	69	0	0	0
Myanmar	135	85	15	0	0	0	0	0
Nepal	238	0	98	1	1	0	0	0
Pakistan	190	97	1	1	1	0	0	0
Sri Lanka	6	0	100	0	0	0	0	0
South America	63	0	0	100	0	0	0	0
Argentina	63	0	0	98	0	0	0	2
Developed countries	**1786**	**1**	**0**	**98**	**1**	**0**	**0**	**0**
Australia	32	0	0	100	0	0	0	0
Greece	1	0	0	100	0	0	0	0
Hungary	7	0	0	0	100	0	0	0
Japan	1	0	0	100	0	0	0	0
Portugal	10	0	0	0	100	0	0	0
South Africa	10	100	0	0	0	0	0	0
Spain	1	0	0	0	100	0	0	0
United States	180	0	0	100	0	0	0	0
Yugoslavia	1	0	0	100	0	0	0	0
CIS	1540	0	0	100	0	0	0	0
World	**28377**	**52**	**12**	**14**	**18**	**1**	**0**	**3**

Source: Accurate figures on millet production and particularly on species-wise composition, are difficult to obtain. These figures are based on official country statistics and FAO estimates for 1981-85 production, revised to obtain the 1992-94 average. The revision was based on relative proportions of the different millets in the 1981-85 production. Updated information on species-wise composition of the 1992-94 production was provided by respondents (usually millet scientists and extension personnel) to ICRISAT questionnaires.

Part III Sorghum and Millet Statistics

Introduction

The tables on pages 57-68 present 34 statistics related to sorghum and millet production and consumption, as well as some basic economic indicators, for countries where the 1992-94 average production of either sorghum or millet exceeded 50 000 tons. Zeros represent negligible quantities consumed, produced or harvested.

Unless otherwise indicated, the regional aggregates (pages 67-68) include all the countries of a particular region for which information was available. Regional totals were calculated by summing the values for all countries in a region and then calculating the mean value. Thus, regional totals may be slightly different from the sum of the average values for each country.

Data sources

Variables 1 and 2: FAOSTATPC (1995) demographic database.

Variables 3: World Bank World Development Report (1993).

Variables 4 to 34. FAOSTATPC database of production and utilization statistics (1994).

Growth rates

Growth rates (variables 15 to 20 and 29 to 34) were calculated using the exponential growth rate,

$Y = b_0(e^{b_1 t})$ linearized as $\ln Y = \ln (b_0) + b_1 t$

where $\ln Y$ = natural logarithm of variable Y, t — time period (years), and b_1 = growth rate of Y.

North Africa and the Middle East

	Egypt	Sudan	Saudi Arabia
General information			
1. Estimated population, 1994 (million)	61.6	27.3	17.4
2. Estimated population growth rate, 1994-2010 (%/yr)	2.3	2.8	4.9
3. Per caput income, 1991 (US$)	610	168	7820
4. Per caput cereal production, 1992-94 (kg/yr)	14.4	173.9	27.0
5. Per caput sorghum production, 1992-94 (kg/yr)	1 3.6	130.0	10.8
6. Per caput millet production, 1992-94 (kg/yr)	0.0	21.2	1.0
Sorghum statistics			
7. Sorghum area harvested, 1992-94 average ('000 ha)	151.0	5769	149.0
8. Sorghum production, 1992-94 average ('000 t)	759.0	3322	176.0
9. Sorghum yield, 1992-94 average (t/ha)	5.03	0.57	1.18
10. Sorghum share in total cereal area, 1992-94 average (%)	6.0	81.0	13.0
11. Sorghum share in total cereal production, 1992-94 average (%)	5.0	77.0	3.7
12. Per caput sorghum consumption, 1972-74 average (kg/yr)	7.9	89.7	7.8
13. Per caput sorghum consumption, 1982-84 average (kg/yr)	2.5	84.9	4.3
14. Per caput sorghum consumption, 1992-94 average (kg/yr)	3.8	92.1	2.9
15. Growth rate of sorghum area, 1975-84 (%/yr)	-2.7	3.5	-19.0
16. Growth rate of sorghum area, 1985-94 (%/yr)	0.7	2.1	17.3
17. Growth rate of sorghum production, 1975-84 (%/yr)	-2.9	3.1	-14.0
18. Growth rate of sorghum production, 1985-94 (%/yr)	4.0	1.4	16.7
19. Growth rate of sorghum yield, 1975-84 (%/yr)	-0.2	-6.6	5.0
20. Growth rate of sorghum yield, 1985-94 (%/yr)	3.3	-0.7	-0.5
Millet statistics			
21. Millet area harvested, 1992-94 average ('000 ha)	0.0	1950	6.0
22. Millet production, 1992-94 average ('000 t)	0.0	547	11.0
23. Millet yield, 1992-94 average (t/ha)	0.0	0.27	1.83
24. Millet share in total cereal area, 1992-94 average (%)	0.0	27.0	0.5
25. Millet share in total cereal production, 1992-94 average (%)	0.0	13.0	0.2
26. Per caput millet consumption, 1972-74 average (kg/yr)	0.0	23.4	7.1
27. Per caput millet consumption, 1982-84 average (kg/yr)	0.0	14.6	0 5
28. Per caput millet consumption, 1992-94 average (kg/yr)	0.0	14.1	0.8
29. Growth rate of millet area, 1975-84 (%/yr)	0.0	0.8	-21.2
30. Growth rate of millet area, 1985-94 (%/yr)	0.0	1.3	10.0
31. Growth rate of millet production, 1975-84 (%/yr)	0.0	-8.2	-12.5
32. Growth rate of millet production 1985-94 (%/yr)	0.0	5.7	10.1
33. Growth rate of millet yield, 1975-84 (%/yr)	0.0	-9.0	8.7
34. Growth rate of millet yield, 1985-94 (%/yr)	0.0	4.4	0.1

Eastern and Southern Africa

	Angola[1]	Ethiopia	Kenya	Mozambique
General information				
1. Estimated population, 1994 (million)	10.7	53.4	27.3	15.5
2. Estimated population growth rate, 1994-2010 (%/yr)	2.4	2.2	3.6	2.2
3. Per caput income, 1991 (US$)	na[2]	120	340	80
4. Per caput cereal production, 1992-94 (kg/yr)	40.0	63.0	95.0	34.0
5. Per caput sorghum production, 1992-94 (kg/yr)		21.0	4.7	8.2
6. Per caput millet production, 1992-94 (kg/yr)	0.6	4.8	2.2	1.2
Sorghum statistics				
7. Sorghum area harvested, 1992-94 average ('000 ha)		913.0	118.0	376.0
8. Sorghum production, 1992-94 average ('000 t)		1161.0	125.0	124.0
9. Sorghum yield, 1992-94 average (t/ha)		1.27	1.05	0.34
10. Sorghum share in total cereal area, 1992-94 average		35.0	7.0	28.0
11. Sorghum share in total cereal production, 1992-94 average (%)		33.0	5.0	25.0
12. Per caput sorghum consumption, 1972-74 average (kg/yr)		24.5	9.5	18.9
13. Per caput sorghum consumption, 1982-84 average (kg/yr)		20.3	1.2	13.3
14. Per caput sorghum consumption, 1992-94 average (kg/yr)		17.0	3.3	9.5
15. Growth rate of sorghum area, 1975-84 (%/yr)		1.4	-7.9	5.3
16. Growth rate of sorghum area, 1985-94 (%/yr)		0.2	-3.1	1.1
17. Growth rate of sorghum production, 1975-84 (%/yr)		1.1	-16.4	-0.2
18. Growth rate of sorghum production, 1985-94 (%/yr)		1.7	-0.2	-7.8
19. Growth rate of sorghum yield, 1975-84 (%/yr)		-0.3	-8.5	-5.5
20. Growth rate of sorghum yield, 1985-94 (%/yr)		1.4	3.0	-8.7
Millet statistics				
21. Millet area harvested, 1992-94 average ('000 ha)	218.7	253.0	88.3	50.6
22. Millet production, 1992-94 average ("000 t)	56.0	265.0	57.0	18.7
23. Millet yield, 1992-94 average (t/ha)	0.26	1.05	0.65	0.37
24. Millet share in total cereal area, 1992-94 average (%)	13.0	10.0	5.0	3.0
25. Millet share in total cereal production, 1992-94 average (%)	15.0	8.0	2.0	3.0
26. Per caput millet consumption, 1972-74 average (kg/yr)	10.8	2.9	6.2	0.9
27. Per caput millet consumption, 1982-84 average (kg/yr)	5.4	4.0	0.2	0.3
28. Per caput millet consumption, 1992-94 average (kg/yr)	6.2	2.0	1.4	0.2
29. Growth rate of millet area, 1975-84 (%/yr)	-1 8	-2.5	-8.9	0.0
30. Growth rate of millet area, 1985-94 (%/yr)	12.2	2.1	2.5	14.7
31. Growth rate of millet production, 1975-84 (%/yr)	-7.5	-2.8	-23.1	-6.4
32. Growth rate of millet production 1985-94 (%/yr)	-0.1	5.5	0.2	12.2
33. Growth rate of millet yield, 1975-84 (%/yr)	-5.7	-0.3	-14.2	-6.4
34. Growth rate of millet yield, 1985-94 (%/yr)	-12.3	3.3	-2.2	-2.5

1. For Angola, millet and sorghum figures are combined under the millet data. Sorghum is estimated to represent about half of the combined figures.

2. Not available.

Eastern and Southern Africa (*continued*)

	Somalia	Tanzania	Uganda	Zambia	Zimbabwe
General information					
1. Estimated population, 1994 (million)	9.0	28.8	20.6	9.1	11.0
2. Estimated population growth rate, 1994-2010 (%/yr)	2.9	3.1	3.3	3.3	3.2
3. Per caput income, 1991 (US$)	na[1]	100	170	420	650
4. Per caput cereal production, 1992-94 (kg/yr)	38.0	134.0	90.0	133.7	166.0
5. Per caput sorghum production, 1992-94 (kg/yr)	15.1	21.4	19.2	3.2	6.4
6. Per caput millet production, 1992-94 (kg/yr)	0.0	8.3	31.8	5.6	6.2
Sorghum statistics					
7. Sorghum area harvested, 1992-94 average ('000 ha)	400.0	663.0	255.0	42.0	132.7
8. Sorghum production, 1992-94 average ('000 t)	143.0	595.0	383.0	27.7	69.0
9. Sorghum yield, 1992-94 average (t/ha)	0.34	0.90	1.50	0.66	0.50
10. Sorghum share in total cereal area, 1992-94 average (%)	89.0	21.0	22.0	3.8	9.0
11, Sorghum share in total cereal production, 1992-94 average (%)	59.0	16.0	21.0	2.3	4.0
12. Per caput sorghum consumption, 1972-74 average (kg/yr)	0.0	5.3	10.3	6.1	13.4
13. Per caput sorghum consumption, 1982-84 average (kg/yr)	18.9	24.7	8.8	1.3	4.2
14. Per caput sorghum consumption, 1992-94 average (kg/yr)	12.4	17.8	14.6	1.6	6.2
15. Growth rate of sorghum area, 1975-84 (%/yr)	1.0	-2.8	-6.0	-17.7	2.9
16. Growth rate of sorghum area, 1985-94 (%/yr)	-2.2	1.3	3.4	0.2	-6.0
17. Growth rate of sorghum production, 1975—84 (%/yr)	4.4	6.7	-4.1	-1 4.8	-5.5
18. Growth rate of sorghum production, 1985-94 (%/yr)	-7.5	-0.7	3.3	-1.4	-7.1
19. Growth rate of sorghum yield, 1975-84 (%/yr)	3.4	9.5	1.9	2.9	-8.4
20. Growth rate of sorghum yield, 1985-94 (%/yr)	-5.5	-2.0	-0. I	-1.6	-1.1
Millet statistics					
21. Millet area harvested, 1992-94 average ('000 ha)	0.0	324.0	405.0	64.0	252.0
22. Millet production, 1992-94 average ('000 t)	0.0	230.0	634.0	49.3	67.0
23. Millet yield, 1992-94 average (t/ha)	0.0	0.71	1.57	0.77	0.26
24. Millet share in total cereal area, 1992-94 average (%)	0.0	10.0	35.0	8.7	18.0
25. Millet share in total cereal production, 1992-94 average (%)	0.0	6.0	35.0	4,1	4.0
26. Per caput millet consumption, 1972-74 average (kg/yr)	0.0	3.3	23.4	9.9	22.9
27. Per caput millet consumption, 1982-84 average (kg/yr)	0.0	10.4	16.0	0.7	7.5
28. Per caput millet consumption, 1992-94 average (kg/yr)	0.0	6.4	25.9	1.3	4.5
29. Growth rate of millet area, 1975-84 (%/yr)	0.0	0.1	-5.9	-22.2	-5.2
30. Growth rate of millet area, 1985-94 (%/yr)	0.0	-0.6	3.2	13.1	-1.6
31. Growth rate of millet production, 1975-84 (%/yr)	0.0	4.9	-5.4	-20.8	-7.1
32. Growth rate of millet production 1985-94 (%/yr)	0.0	-7.0	3.9	13.6	-11.4
33. Growth rate of millet yield, 1975-84 (%/yr)	0.0	4.8	0.5	1.4	-1.9
34. Growth rate of millet yield, 1985-94 (%/yr)	0.0	-6.5	0.7	0.5	-10.0

1. Not available.

Western and Central Africa

	Benin	Burkina Faso	Cameroon	Chad	Cdte d'Ivoire
General information					
1. Estimated population, 1994 (million)	5.2	10.0	12.8	6.2	13.8
2. Estimated population growth rate, 1994-2010 (%/yr)	2.6	2.4	2.7	2.1	3.9
3. Per caput income, 1991 (US$)	380	290	850	220	690
4. Per caput cereal production, 1992-94 (kg/yr)	120.7	249.0	75.0	134.0	99.0
5. Per caput sorghum production, 1992-94 (kg/yr)	22.0	125.6	29.8	60.7	2.3
6. Per caput millet production, 1992-94 (kg/yr)	5.0	79.5	4.4	43.8	5.3
Sorghum statistics					
7. Sorghum area harvested, 1992-94 average ('000 ha)	142.0	1398.0	497.0	550.0	50.3
8. Sorghum production, 1992-94 average ('000 t)	110.0	1251.0	373.0	391.0	30.0
9. Sorghum yield, 1992-94 average (t/ha)	0.78	0.90	0.75	0.71	0.60
10. Sorghum share in total cereal area, 1992-94 average (%)	21.0	49.0	63.0	42.0	4.0
11. Sorghum share in total cereal production, 1992-94 average (%)	17.5	50.0	40.0	45.0	2.0
12. Per caput sorghum consumption, 1972-74 average (kg/yr)	16.1	67.7	25.6	55.0	1.9
13. Per caput sorghum consumption, 1982-84 average (kg/yr)	14.4	67.0	27.2	36.4	1.0
14. Per caput sorghum consumption, 1992-94 average (kg/yr)	18.1	108.0	28.5	47.7	1.1
15. Growth rate of sorghum area, 1975-84 (%/yr)	3.9	-0.9	24.0	-7.3	-4.5
16. Growth rate of sorghum area, 1985-94 (%/yr)	3.2	2.4	1.6	3.7	4.7
17. Growth rate of sorghum production, 1975-84 (%/yr)	0.6	-0.8	-1.9	-8.1	-7.2
18. Growth rate of sorghum production, 1985-94 (%/yr)	3.4	4.8	0.1	4.8	4.2
19. Growth rate of sorghum yield, 1975-84 (%/yr)	-3.3	0.1	-25.9	-0.8	-2.7
20. Growth rate of sorghum yield, 1985-94 (%/yr)	0.2	2.4	-1.5	1.1	-0.5
Millet statistics					
21. Millet area harvested, 1992-94 average ('000 ha)	37.7	1239.0	54.0	591.0	84.0
22. Millet production, 1992-94 average ('000 t)	25.0	793.0	55.0	282.0	71.0
23. Millet yield, 1992-94 average (t/ha)	0.66	0.64	1.01	0.48	0.84
24. Millet share in total cereal area, 1992-94 average (%)	5.6	43.0	7.0	43.0	6.0
25. Millet share in total cereal production, 1992-94 average (%)	4.0	32.0	6.0	31.0	5.0
26. Per caput millet consumption, 1972-74 average (kg/yr)	2.1	39.8	10.0	43.0	2.6
27. Per caput millet consumption, 1982-84 average (kg/yr)	1.0	46.1	8.4	19.4	3.0
28. Per caput millet consumption, 1992-94 average (kg/yr)	3.1	68.5	3.8	33.7	3.5
29. Growth rate of millet area, 1975-84 (%/yr)	2.5	-0.4	-7.1	-9.1	-3.8
30. Growth rate of millet area, 1985-94 (%/yr)	7.1	1.7	0.7	2.6	3.3
31. Growth rate of millet production, 1975-84 (%/yr)	9.4	1.2	-8.6	-9.1	-5.7
32. Growth rate of millet production 1985-94 (%/yr)	8.0	2.9	0.6	1.4	8.0
33. Growth rate of millet yield, 1975-84 (%/yr)	6.9	1.6	-1.5	0.0	-1.9
34. Growth rate of millet yield, 1985-94 (%/yr)	0.9	1.2	-0.1	-1.2	4.5

Western and Central Africa (*continued*)

	Ghana	Mali	Mauritania	Niger	Nigeria	Senegal
General information						
1. Estimated population, 1994 (million)	16.9	10.5	2.2	8.8	108.5	8.1
2. Estimated population growth rate, 1994-2010 (%/yr)	2.7	2.5	2.4	3.1	2.8	2.8
3. Per caput income, 1991 (US$)	400	280	510	300	340	720
4, Per caput cereal production, 1992-94 (kg/yr)	88.0	221.0	70.5	262	128.0	117
5. Per caput sorghum production, 1992-94 (kg/yr)	17.4	82.8	39.2	46.8	57.5	14.8
6. Per caput millet production, 1992-94 (kg/yr)	10.1	82.6	2.0	209.4	43.9	66.8
Sorghum statistics						
7. Sorghum area harvested, 1992-94 average ('000 ha)	310.7	957.0	149.3	2261	5700.0	133.0
8. Sorghum production, 1992-94 average ('000 t)	282.0	733.0	85.3	415.0	6100.0	116.0
9. Sorghum yield, 1992-94 average (t/ha)	0.91	0.76	0.57	0.19	1.05	0.87
10. Sorghum share in total cereal area, 1992-94 average (%)	25.0	43.0	78.0	33.0	39.0	11.0
11. Sorghum share in total cereal production, 1992-94 average (%)	20.0	38.0	54.0	20.0	34.0	11.0
12. Per caput sorghum consumption, 1972-74 average (kg/yr)	11.5	43.4	30.5	50.4	41.3	21.2
13. Per caput sorghum consumption, 1982-84 average (kg/yr)	5.7	53.1	23.1	47.3	39.4	25.7
14. Per caput sorghum consumption 1992-94 average (kg/yr)	10.3	67.3	19.4	39.6	39.5	10.5
15. Growth rate of sorghum area, 1975-84 (%/yr)	1.7	-0.3	4.2	6.2	-4.9	-2.0
16. Growth rate of sorghum area, 1985-94 (%/yr)	5.4	10.9	0.0	9.4	3.3	-2.2
17. Growth rate of sorghum production, 1975-84 (%/yr)	-5.0	2.3	-7.2	0.4	4.7	-1.8
18. Growth rate of sorghum production, 1985-94 (%/yr)	8.7	6.0	-0.6	1.8	2.0	-3.1
19. Growth rate of sorghum yield, 1975-84 (%/yr)	-6.7	2.6	-11.4	-5.8	9.6	0.2
20. Growth rate of sorghum yield, 1985-94 (%/yr)	3.3	-4.4	-0.6	-6.9	-1.3	-0.9
Millet statistics						
21. Millet area harvested, 1992-94 average ('000 ha)	202.0	1205.0	15.7	4866.0	5200.0	895.0
22. Millet production, 1992-94 average ('000 t)	166.0	732.0	4.3	1858.0	4620.0	549.0
23. Millet yield, 1992-94 average (t/ha)	0.83	0.60	0.27	0.38	0.89	0.61
24. Millet share in total cereal area, 1992-94 average (%)	17.0	54.0	8.0	*72.0*	32.0	75.0
25. Millet share in total cereal production, 1992-94 average (%)	11.0	38.0	2.5	91.0	26.0	57.0
26. Per caput millet consumption, 1972-74 average (kg/yr)	8.7	64.1	43.0	153.5	37.8	62.3
27. Per caput millet consumption, 1982-84 average (kg/yr)	5.7	63.3	9.4	159.2	24.7	55.6
28. Per caput millet consumption, 1992-94 average (kg/yr)	7.9	74.6	1.9	162.4	31.5	61.6
29. Growth rate of millet area, 1975-84 (%/yr)	-1.5	2.0	-14.8	4.8	-9.4	0.4
30. Growth rate of millet area, 1985-94 (%/yr)	0.4	5.4	2.0	6.2	7.0	-1.2
31. Growth rate of millet production, 1975-84 (%/yr)	-6.2	1.8	-3.1	0.4	-0.2	-2.1
32. Growth rate of millet production 1985-94 (%/yr)	3.0	-1.2	-9.0	4.7	2.4	-1.8
33. Growth rate of millet yield, 1975-84 (%/yr)	-4.7	-0.2	11.7	-4.4	9.2	-2.5
34. Growth rate of millet yield, 1985-94 (%/yr)	2.6	-6.2	-11.0	-1.5	-4.3	-0.6

Asia

	China	India	Korea DPR	Myanmar
General information				
1. Estimated population, 1994 (million)	1208.8	918.5	23.4	45.5
2. Estimated population growth rate, 1994-2010 (%/yr)	1.8	2.2	2.2	2.2
3. Per caput income, 1991 (US$)	370	330	6330	na[1]
4. Per caput cereal production, 1992-94 (kg/yr)	340	224	262	373
5. Per caput sorghum production, 1992-94 (kg/yr)	4.7	12.5	0.45	0.0
6. Per caput millet production, 1992-94 (kg/yr)	3.1	11,9	1.8	3.0
Sorghum statistics				
7. Sorghum area harvested, 1992-94 average ('000 ha)	1363	12552	10.0	0.0
8. Sorghum production, 1992-94 average ('000 t)	5614	11232	10.3	0.0
9. Sorghum yield, 1992-94 average (t/ha)	4.11	0.89	1.03	0.0
10. Sorghum share in total cereal area, 1992-94 average (%)	2.0	13.0	1.0	0.0
11. Sorghum share in total cereal production, 1992-94 average (%)	1.0	6.0	0.0	0.0
12. Per caput sorghum consumption, 1972-74 average (kg/yr)	7.2	14.2	1.3	0.0
13. Per caput sorghum consumption, 1982-84 average (kg/yr)	*4.6*	13.9	0.7	0.0
14. Per caput sorghum consumption, 1992-94 average (kg/yr)	2.6	10.7	0.4	0.0
15. Growth rate of sorghum area, 1975-84 (%/yr)	*-6.6*	0.2	-7.4	0.0
16. Growth rate of sorghum area, 1985-94 (%/yr)	-4.7	-3.5	0.0	0.0
17. Growth rate of sorghum production, 1975-84 (%/yr)	-1.4	1.2	-4.5	0.0
18. Growth rate of sorghum production, 1985-94 (%/yr)	0.3	0.2	-4.7	0.0
19. Growth rate of sorghum yield, 1975-84 (%/yr)	5.2	1.0	2.9	0.0
20. Growth rate of sorghum yield, 1985-94 (%/yr)	5.2	3.8	-4.7	0.0
Millet statistics				
21. Millet area harvested, 1992-94 average ('000 ha)	1901	13953	40.0	203.0
22. Millet production, 1992-94 average ('000 t)	3671	10703	40.0	135.0
23. Millet yield, 1992-94 average (t/ha)	1.97	0.76	1.0	0.66
24. Millet share in total cereal area, 1992-94 average (%)	2.0	14.0	10.0	3.0
25. Millet share in total cereal production, 1992-94 average (%)	1.0	5.0	2.0	1.0
26. Per caput millet consumption, 1972-74 average (kg/yr)	*6.6*	13.1	3.2	1.7
27. Per caput millet consumption, 1982-84 average (kg/yr)	5.2	12.7	2.0	4.7
28. Per caput millet consumption, 1992-94 average (kg/yr)	2.7	10.2	1.4	2.5
29. Growth rate of millet area, 1975-84 (%/yr)	-2.7	-1.0	-3.5	2.9
30. Growth rate of millet area, 1985-94 (%/yr)	*-6.6*	-2.0	-3.2	1.2
31. Growth rate of millet production, 1975-84 (%/yr)	1.6	0.3	-2.0	18.6
32. Growth rate of millet production 1985-94 (%/yr)	-4.4	3.6	-6.1	-5.2
33. Growth rate of millet yield, 1975-84 (%/yr)	4.3	1.3	1.5	15.7
34. Growth rate of millet yield, 1985-94 (%/yr)	2.4	5.6	-2.9	-6.3

1. Not available.

Asia (*continued*)

	Nepal	Pakistan	Thailand
General information			
1. Estimated population, 1994 (million)	21.4	136.6	58.1
2. Estimated population growth rate, 1994-2010 (%/yr)	2.5	3.0	2.4
3. Per caput income, 1991 (US$)	180	400	1570
4. Per caput cereal production, 1992-94 (kg/yr)	246	173	40.4
5. Per caput sorghum production, 1992-94 (kg/yr)	0.0	1.8	4.1
6. Per caput millet production, 1992-94 (kg/yr)	11.4	1.4	0.0
Sorghum statistics			
7. Sorghum area harvested, 1992-94 average ('000 ha)	0.0	402.0	173.0
8. Sorghum production, 1992-94 average ('000 t)	0.0	238	234.0
9. Sorghum yield, 1992-94 average (t/ha)	0.0	0.59	1.36
10. Sorghum share in total cereal area, 1992-94 average (%)	0.0	3.0	1.6
11. Sorghum share in total cereal production, 1992-94 average (%)	0.0	1.0	1.0
12. Per caput sorghum consumption, 1972-74 average (kg/yr)	0.0	3.9	0.0
13. Per caput sorghum consumption, 1982-84 average (kg/yr)	0.0	1.0	0.03
14. Per caput sorghum consumption, 1992-94 average (kg/yr)	0.0	0.8	0.1
15. Growth rate of sorghum area, 1975-84 (%/yr)	0.0	-2.8	8.5
16. Growth rate of sorghum area, 1985-94 (%/yr)	0.0	1.0	-3.0
17. Growth rate of sorghum production, 1975-84 (%/yr)	0.0	-2.7	8.8
18. Growth rate of sorghum production, 1985-94 (%/yr)	0.0	1.1	-1.9
19. Growth rate of sorghum yield, 1975-84 (%/yr)	0.0	0.1	0.3
20. Growth rate of sorghum yield, 1985-94 (%/yr)	0.0	0.2	1.1
Millet statistics			
21. Millet area harvested, 1992-94 average ('000 ha)	209	433	0.0
22. Millet production, 1992-94 average ('000 t)	238	190	0.0
23. Millet yield, 1992-94 average (t/ha)	1.14	0.44	0.0
24. Millet share in total cereal area, 1992-94 average (%)	7.0	4.0	0.0
25. Millet share in total cereal production, 1992-94 average (%)	5.0	1.0	0.0
26. Per caput millet consumption, 1972-74 average (kg/yr)	9.7	3.8	0.0
27. Per caput millet consumption, 1982-84 average (kg/yr)	4.9	1.1	0.0
28. Per caput millet consumption, 1992-94 average (kg/yr)	10.25	0.83	0.0
29. Growth rate of millet area, 1975-84 (%/yr)	1.3	-1.9	0.0
30. Growth rate of millet area, 1985-94 (%/yr)	4.2	-2.1	0.0
31. Growth rate of millet production, 1975-84 (%/yr)	-1.0	-2.4	0.0
32. Growth rate of millet production 1985-94 (%/yr)	7.4	-2.3	0.0
33. Growth rate of millet yield, 1975-84 (%/yr)	-2.3	-0.5	0.0
34. Growth rate of millet yield, 1985-94 (%/yr)	3.0	-0.3	0.0

Latin America and the Caribbean

	Argentina	Brazil	Colombia	El Salvador	Guatemala
General information					
1. Estimated population, 1994 (million)	34.2	159.1	34.5	5.6	10.3
2. Estimated population growth rate, 1994-2010 (%/yr)	1.5	2.3	2.2	2.2	2.8
3. Per caput income, 1991 (US$)	2700	2940	1260	1080	930
4. Per caput cereal production, 1992-94 (kg/yr)	741	278	107	167	150
5. Per caput sorghum production, 1992-94 (kg/yr)	76.9	1.8	20.4	36.7	8.1
6. Per caput millet production, 1992-94 (kg/yr)	1.9	0.0	0.0	0.0	0.0
Sorghum statistics					
7. Sorghum area harvested, 1992-94 average ('000 ha)	698	147	223	135	68.0
8. Sorghum production, 1992-94 average ('000 t)	2596	275	688	200	80.0
9. Sorghum yield, 1992-94 average (t/ha)	3.71	1.88	3.08	1.49	1.19
10. Sorghum share in total cereal area, 1992-94 average (%)	8.0	0.0	15.0	28.0	8.0
11. Sorghum share in total cereal production, 1992-94 average (%)	10.0	0.0	19.0	22.0	5.0
12. Per caput sorghum consumption, 1972-74 average (kg/yr)	0.0	0.0	0.0	20.8	0.0
13. Per caput sorghum consumption, 1982-84 average (kg/yr)	0.0	0.0	2.8	15.5	2.5
14. Per caput sorghum consumption, 1992-94 average (kg/yr)	0.0	0.0	1.0	10.4	1.9
15. Growth rate of sorghum area, 1975-84 (%/yr)	1.9	2.9	6.5	-1.9	3.1
16. Growth rate of sorghum area, 1985-94 (%/yr)	-10.0	-3.8	0.2	1.4	0.3
17. Growth rate of sorghum production, 1975-84 (%/yr)	4.0	-0.2	5.6	-3.2	6.2
18. Growth rate of sorghum production, 1985-94 (%/yr)	-7.7	-2.7	2.3	10.1	-3.7
19. Growth rate of sorghum yield, 1975-84 (%/yr)	2.1	-3.1	-0.9	-1.3	3.1
20. Growth rate of sorghum yield, 1985-94 (%/yr)	2.4	1.1	2.1	8.6	-4.1
Millet statistics					
21. Millet area harvested, 1992-94 average ('000 ha)	41.0	0.0	0.0	0.0	0.0
22. Millet production, 1992-94 average ('000 t)	63.0	0.0	0.0	0.0	0.0
23. Millet yield, 1992-94 average (t/ha)	1.53	0.0	0.0	0.0	0.0
24. Millet share in total cereal area, 1992-94 average (%)	0.4	0.0	0.0	0.0	0.0
25. Millet share in total cereal production, 1992-94 average (%)	0.2	0.0	0.0	0.0	0.0
26. Per caput millet consumption, 1972-74 average (kg/yr)	0.0	0.0	0.0	0.0	0.0
27. Per caput millet consumption, 1982-84 average (kg/yr)	0.0	0.0	0.0	0.0	0.0
28. Per caput millet consumption, 1992-94 average (kg/yr)	0.0	0.0	0.0	0.0	0.0
29. Growth rate of millet area, 1975-84 (%/yr)	-6.9	0.0	0.0	0.0	0.0
30. Growth rate of millet area, 1985-94 (%/yr)	-10.6	0.0	0.0	0.0	0.0
31. Growth rate of millet production, 1975-84 (%/yr)	-7.2	0.0	0.0	0.0	0.0
32. Growth rate of millet production 1985-94 (%/yr)	-7.7	0.0	0.0	0.0	0.0
33. Growth rate of millet yield, 1975-84 (%/yr)	-0.3	0.0	0.0	0.0	0.0
34. Growth rate of millet yield, 1985-94 (%/yr)	3.1	0.0	0.0	0.0	0.0

Latin America and the Caribbean (*continued*)

	Haiti	Honduras	Mexico	Nicaragua	Uruguay	Venezuela
General information						
1. Estimated population, 1994 (million)	7.0	5.49	91.8	4.2	3.1	21.3
2. Estimated population growth rate, 1994-2010 (%/yr)	1.8	3.2	2.7	3.0	0.6	3.1
3. Per caput income, 1991 (US$)	370	580	3030	460	2840	2730
4. Per caput cereal production, 1992-94 (kg/yr)	60	121	293	129	129	84
5. Per caput sorghum production, 1992-94 (kg/yr)	12.7	14.8	49.1	23.2	35.0	21.6
6. Per caput millet production, 1992-94 (kg/yr)	0.0	0.0	0.1	0.0	0.0	0.0
Sorghum statistics						
7. Sorghum area harvested, 1992-94 average ('000 ha)	111	72.7	1277	52.0	37	210
8. Sorghum production, 1992-94 average ('000 t)	87.0	82.0	4382	94.0	no	441
9. Sorghum yield, 1992-94 average (t/ha)	0.78	1.13	3.43	1.80	2.94	2.09
10. Sorghum share in total cereal area, 1992-94 average (%)	25.0	93.0	13.0	17.0	7.0	29.0
11. Sorghum share in total cereal production, 1992-94 average (%)	21.0	95.0	17.0	18.0	7.0	25.0
12. Per caput sorghum consumption, 1972-74 average (kg/yr)	25.5	5.9	0.0	2.37	0.0	0.0
13. Per caput sorghum consumption, 1982-84 average (kg/yr)	17.0	2.7	2.3	6.3	0.0	0.0
14. Per caput sorghum consumption, 1992-94 average (kg/yr)	10.4	5.9	2.4	7.9	0.0	0.0
15. Growth rate of sorghum area, 1975-84 (%/yr)	1.6	-0.9	1.8	-1.8	-2.4	16.0
16. Growth rate of sorghum area, 1985-94 (%/yr)	-5.2	9.0	-4.4	-5.6	-5.7	-6.2
17. Growth rate of sorghum production, 1975-84 (%/yr)	-1.0	1.3	2.9	8.8	1.5	17.2
18. Growth rate of sorghum production, 1985-94 (%/yr)	-6.4	13.2	-5.5	-5.9	-3.2	-5.4
19. Growth rate of sorghum yield, 1975-84 (%/yr)	-2.6	2.2	1.1	10.6	3.9	1.2
20. Growth rate of sorghum yield, 1985-94 (%/yr)	-1.2	4.2	-1.2	-0.3	2.7	0.9
Millet statistics						
21. Millet area harvested, 1992-94 average ('000 ha)	0.0	0.0	4.0	0.0	0.0	0.0
22. Millet production, 1992-94 average ('000 t)	0.0	0.0	9.0	0.0	0.0	0.0
23. Millet yield, 1992-94 average (t/ha)0.0	0.0	0.0	2.25	0.0	0.0	0.0
24. Millet share in total cereal area, 1992-94 average (%)	0.0	0.0	0.04	0.0	0.0	0.0
25. Millet share in total cereal production, 1992-94 average (%)	0.0	0.0	0.03	0.0	0.0	0.0
26. Per caput millet consumption, 1972-74 average (kg/yr)	0.0	0.0	0.0	0.0	0.0	0.0
27. Per caput millet consumption, 1982-84 average (kg/yr)	0.0	0.0	0.0	0.0	0.0	0.0
28. Per caput millet consumption, 1992-94 average (kg/yr)	0.0	0.0	0.0	0.0	0.0	0.0
29. Growth rate of millet area, 1975-84 (%/yr)	0.0	0.0	0.0	0.0	0.0	0.0
30. Growth rate of millet area, 1985-94 (%/yr)	0.0	0.0	0.0	0.0	0.0	0.0
31. Growth rate of millet production, 1975-84 (%/yr)	0.0	0.0	0.0	0.0	0.0	0.0
32. Growth rate of millet production, 1985-94 (%/yr)	0.0	0.0	0.0	0.0	0.0	0.0
33. Growth rate of millet yield, 1975-84 (%/yr)	0.0	0.0	0.0	0.0	0.0	0.0
34. Growth rate of millet yield, 1985-94 (%/yr)	0.0	0.0	0.0	0.0	0.0	0.0

Developed Countries

	Australia	European Union (12 countries)	South Africa	United States
General information				
1. Estimated population, 1994 (million)	17.8	348.9	40.5	260.6
2. Estimated population growth rate, 1994-2010 (%/yr)	1.6	0.4	2.5	1.0
3. Per caput income, 1991 (US$)	15,945	2896	2560	22,240
4. Per caput cereal production, 1992-94 (kg/yr)	1523	710	210	1189
5. Per caput sorghum production, 1992-94 (kg/yr)	55.5	1.9	9.0	67.9
6. Per caput millet production, 1992-94 (kg/yr)	1.8	0.0	6.8	0.7
Sorghum statistics				
7. Sorghum area harvested, 1992-94 average ('000 ha)	499	124	179	4051
8. Sorghum production, 1992-94 average ('000 t)	975	697	366	17,503
9. Sorghum yield, 1992-94 average (t/ha)	1.90	5.59	1.94	4.29
10. Sorghum share in total cereal area, 1992-94 average (%)	4.0	0.0	3.0	6.0
11. Sorghum share in total cereal production, 1992-94 average (%)	4.0	0.0	4.0	6.0
12. Per caput sorghum consumption, 1972-74 average (kg/yr)	0.0	0.0	4.4	0.7
13. Per caput sorghum consumption, 1982-84 average (kg/yr)	0.0	0.0	1.9	0.5
14. Per caput sorghum consumption, 1992-94 average (kg/yr)	0.0	0.0	4.8	0.5
15. Growth rate of sorghum area, 1975-84 (%/yr)	5.1	-3.8	-1.3	-1.5
16. Growth rate of sorghum area, 1985-94 (%/yr)	-6.8	6.8	-8.2	-4.7
17. Growth rate of sorghum production, 1975-84 (%/yr)	5.3	-1.2	-2.2	-0.5
18. Growth rate of sorghum production, 1985-94 (%/yr)	-7.3	9.0	-6.6	-4.7
19. Growth rate of sorghum yield, 1975-84 (%/yr)	0.2	2.6	-0.9	1.0
20. Growth rate of sorghum yield, 1985-94 (%/yr)	-0.6	2.1	1.8	0.0
Millet statistics				
21. Millet area harvested, 1992-94 average ('000 ha)	31.0	15	212.0	150
22. Millet production, 1992-94 average ('000 t)	32.0	15	39.0	180
23. Millet yield, 1992-94 average (t/ha)	1.00	1.00	0.18	1.20
24. Millet share in total cereal area, 1992-94 average (%)	0.0	0.0	0.0	0.0
25. Millet share in total cereal production, 1992-94 average (%)	0.0	0.0	0.0	0.0
26. Per caput millet consumption, 1972-74 average (kg/yr)	0.0	0.0	0.5	0.0
27. Per caput millet consumption, 1982-84 average (kg/yr)	0.0	0.0	7.7	0.0
28. Per caput millet consumption, 1992-94 average (kg/yr)	0.0	0.0	6.3	0.0
29. Growth rate of millet area, 1975-84 (%/yr)	3.7	0.0	0.0	6.3
30. Growth rate of millet area, 1985-94 (%/yr)	-1.3	0.0	11.6	0.3
31. Growth rate of millet production, 1975-84 (%/yr)	5.3	-8.2	0.0	6.4
32. Growth rate of millet production 1985-94 (%/yr)	-2.0	0.0	-2.9	0.3
33. Growth rate of millet yield, 1975-84 (%/yr)	1.6	-8.2	0.0	0.1
34. Growth rate of millet yield, 1985-94 (%/yr)	-0.8	0.0	-13.0	0.0

Regional Aggregates

	Developing countries	Developed countries
General information		
1. Estimated population, 1994 (million)	4350.9	1278.8
2. Estimated population growth rate, 1994-2010 (%/yr)	2.2	0.8
3. Per caput income, 1991 (US$)	829	20,253
4. Per caput cereal production, 1992-94 (kg/yr)	254	663
5. Per caput sorghum production, 1992-94 (kg/yr)	10.4	15.4
6. Per caput millet production, 1992-94 (kg/yr)	6.3	1.4
Sorghum statistics		
7. Sorghum area harvested, 1992-94 average ('000 ha)	40,000	4993
8. Sorghum production, 1992-94 average ('000 t)	44,200	19,659
9. Sorghum yield, 1992-94 average (t/ha)	1.11	3.91
10. Sorghum share in total cereal area, 1992-94 average (%)	9.0	2.0
11. Sorghum share in total cereal production, 1992-94 average (%)	1.0	2.0
12. Per caput sorghum consumption, 1972-74 average (kg/yr)	8.3	0.1
13. Per caput sorghum consumption, 1982-84 average (kg/yr)	7.3	0.3
14. Per caput sorghum consumption, 1992-94 average (kg/yr)	6.0	0.2
15. Growth rate of sorghum area, 1975-84 (%/yr)	-0.5	-0.9
16. Growth rate of sorghum area, 1985-94 (%/yr)	-0.6	-4.9
17. Growth rate of sorghum production, 1975-84 (%/yr)	1.2	-0.2
18. Growth rate of sorghum production, 1985-94 (%/yr)	-0.7	-4.6
19. Growth rate of sorghum yield, 1975-84 (%/yr)	1.7	0.7
20. Growth rate of sorghum yield, 1985-94 (%/yr)	-0.1	0.3
Millet statistics		
21. Millet area harvested, 1992-94 average ('000 ha)	35,600	2491
22. Millet production, 1992-94 average ('000 t)	26,600	1786
23. Millet yield, 1992-94 average (t/ha)	0.75	0.70
24. Millet share in total cereal area, 1992-94 average (%)	8.0	1.0
25. Millet share in total cereal production, 1992-94 average (%)	2.0	0.0
26. Per caput millet consumption, 1972-74 average (kg/yr)	7.1	0.0
27. Per caput millet consumption, 1982-84 average (kg/yr)	6.0	0.0
28. Per caput millet consumption, 1992-94 average (kg/yr)	5.1	0.4
29. Growth rate of millet area, 1975-84 (%/yr)	-1.6	0.6
30. Growth rate of millet area, 1985-94 (%/yr)	0.6	-1.6
31. Growth rate of millet production, 1975-84 (%/yr)	0.2	2.5
32. Growth rate of millet production 1985-94 (%/yr)	1.3	-8.2
33. Growth rate of millet yield, 1975-84 (%/yr)	1.8	1.9
34. Growth rate of millet yield, 1985-94 (%/yr)	0.6	-6.7

Regional Aggregates (*continued*)

	Africa	Asia	Latin America and the Caribbean	North America	Europe
General information					
1. Estimated population, 1994 (million)	708.2	3339.0	473.5	448.9	505.1
2. Estimated population growth rate, 1994-2010 (%/yr)	2.8	2.1	2.3	1.5	0.5
3. Per caput income, 1991 (US$)	370	322	2390	22375	19843
4. Per caput cereal production, 1992-94 (kg/yr)	134	268	180	902.5	511.6
5. Per caput sorghum production, 1992-94 (kg/yr)	26.5	5.7	33.2	51.3	0.4
6. Per caput millet production, 1992-94 (kg/yr)	17.6	4.8	0.0	0.4	0.1
Sorghum statistics					
7. Sorghum area harvested, 1992-94 average ('000 ha)	21,800	15,110	3095	5780	39.0
8. Sorghum production, 1992-94 average ('000 t)	17,100	17,975	9273	22,512	45.0
9. Sorghum yield, 1992-94 average (t/ha)	0.78	1.19	3.0	3.89	1.13
10. Sorghum share in total cereal area, 1992-94 average (%)	26.0	5.0	6.5	6.0	0.2
11. Sorghum share in total cereal production, 1992-94 average (%)	17.0	2.0	7.8	5.5	0.3
12. Per caput sorghum consumption, 1972-74 average (kg/yr)	19.6	7.0	13.7	0.2	0.0
13. Per caput sorghum consumption, 1982-84 average (kg/yr)	19.2	6.0	10.7	0.4	0.0
14. Per caput sorghum consumption, 1992-94 average (kg/yr)	18.6	4.1	8.3	0.5	0.0
15. Growth rate of sorghum area, 1975-84 (%/yr)	-0.2	-1.3	2.3	-0.7	-3.7
16. Growth rate of sorghum area, 1985-94 (%/yr)	2.9	-3.4	-5.5	-4.5	-3.4
17. Growth rate of sorghum production, 1975-84 (%/yr)	0.7	-0.2	3.7	0.3	-1.8
18. Growth rate of sorghum production, 1985-94 (%/yr)	1.7	0.4	-5.3	-4.8	-7.7
19. Growth rate of sorghum yield, 1975-84 (%/yr)	0.9	1.1	1.4	1.0	1.9
20. Growth rate of sorghum yield, 1985-94 (%/yr)	-1.2	3.9	0.2	-0.3	-4.5
Millet statistics					
21. Millet area harvested, 1992-94 average ('000 ha)	18,500	16,994	41.7	154.0	14.0
22. Millet production, 1992-94 average ('000 t)	11,360	15,171	71.7	189.0	17.0
23. Millet yield, 1992-94 average (t/ha)	0.61	0.89	1.7	1.23	1.21
24. Millet share in total cereal area, 1992-94 average (%)	20.0	5.7	0.08	0.16	0.0
25. Millet share in total cereal production, 1992-94 average (%)	10.6	1.6	0.06	0.04	0.0
26. Per caput millet consumption, 1972-74 average (kg/yr)	14.5	6.4	0.0	0.0	0.0
27. Per caput millet consumption, 1982-84 average (kg/yr)	11.4	5.8	0.0	0.0	0.0
28. Per caput millet consumption, 1992-94 average (kg/yr)	13.5	4.2	0.0	0.0	0.0
29. Growth rate of millet area, 1975-84 (%/yr)	-2.1	-1.3	-6.8	6.3	-12.1
30. Growth rate of millet area, 1985-94 (%/yr)	4.5	-2.5	-10.2	1.9	7.6
31. Growth rate of millet production, 1975-84 (%/yr)	-1.1	0.8	-7.2	6.4	-7.5
32. Growth rate of millet production 1985-94 (%/yr)	2.0	0.7	-6.1	2.2	4.0
33. Growth rate of millet yield, 1975-84 (%/yr)	1.0	2.1	-0.4	0.1	4.6
34. Growth rate of millet yield, 1985-94 (%/yr)	-2.3	3.3	4.6	0.3	-3.3

The world sorghum and millet economies: facts, trends and outlook is the result of a collaborative study conducted by FAO and ICRISAT. It reviews the current structure of the world economies of the two crops and analyses the supply and demand situations, both current and projected. Several trends emerging from this analysis are discussed, along with possible implications for research. The paper also examines the major constraints to production of sorghum and millet and policy options that could help increase the output and quality of these crops throughout the semi-arid tropics.

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