An analysis of availability and utilization of sorghum grain in India

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Citation: Parthasarathy Rao P, Basavaraj G, Ahmad W and Bhagavatula S. 2010. An analysis of availability and utilization of sorghum grain in India. Journal of SAT Agricultural Research 8.

Introduction

Sorghum (*Sorghum bicolor*) is one of the major cereal crops consumed in India after rice (*Oryza sativa*) and wheat (*Triticum aestivum*). The crop is primarily produced in Maharashtra and southern states of Karnataka and Andhra Pradesh. These three states together account for close to 80% of the all-India production. Madhya Pradesh, Gujarat and Rajasthan are the other states producing sorghum. India is the third largest producer of sorghum in the world with 7.15 million tons during 2007 and almost entire production of sorghum (95%) in the country comes from the above regions/states (GOI 2007).

Besides grain, sorghum stover is an important feed in the livestock sector in India for draft and dairy animals particularly in the dry seasons when other feed resources are in short supply. Hence, dual purpose types that produce both grain and stover are the preferred types (Kelley et al. 1993, Kelley and Parthasarathy Rao 1994, Hall 2000).

In the last two decades the nature and composition of utilization of sorghum grain has undergone a change from staple food to industrial uses such as livestock and poultry feed, potable alcohol, starch and ethanol production (Kleih et al. 2000). Of these, the fastest growing sectors are the poultry feed and potable alcohol sectors. For example, poultry production in India is expected to grow at 15% to 20% per annum for broilers and 10% to 15% for layers, leading to a corresponding expansion in demand for feed (Parthasarathy Rao and Birthal 2008). Additionally, new value added/processed food products for human consumption are emerging such as popped sorghum, *papad*, porridge, *rava* and as an ingredient for Indian dishes like *dosa*, *khichdi*, etc which, though in the nascent stage, are likely to be significant avenues for diversifying utilization trends of sorghum.

Sorghum production in India, which was characterized by subsistence cultivation during 1970s with small marketable surpluses, is being geared to a more market oriented production owing to the change in crop utilization in many other alternative uses. However, data on utilization as staple and alternative uses are not readily available. To fill this lacuna, an attempt has been made in this paper to compile data on utilization of sorghum for food use and its trends over the years using consumer expenditure survey data published by National Sample Survey Organization (NSSO) (Ministry of Planning and Programme Implementation, Government of India, New Delhi). Such an analysis juxtaposed with sorghum production/availability would provide estimates of sorghum utilized as staple food and with suitable assumptions for other uses (seed, wastage, etc). The residual would then be the quantity available for alternative uses including processed food.

The key research questions that this paper tries to address are:

- Trends in area and production of sorghum [*kharif* (rainy season) and *rabi* (postrainy season)];
- Trends in per capita consumption of sorghum for food (staple) use (all-India and state level);
- Bifurcation and quantification of sorghum consumption for food (staple) and alternative uses (all-India level); and
- Estimation of utilization for *kharif* and *rabi* sorghum.

The estimates thus obtained on utilization of sorghum for food and other uses and their trends would help to understand the magnitude of the changes in utilization over the years that would help researchers (crop scientists and breeders) and policy makers concentrate their efforts on prioritizing the needs for the sorghum sector as a whole.

Data source and methodology

The main data source for this study is NSSO, which publishes data on household consumer expenditure (food and non-food) for rural and urban consumers in India every five years. The data considered for the present study includes seven NSSO quinquennial rounds, namely, the 27th (October 1972–September 1973), 32nd

(July 1977–June 1978), 38th (January–December 1983), 43rd (July 1987–June 1988), 50th (July 1993–June 1994), 55th (July 1999–June 2000) and 61st (July 2004–June 2005). Information on monthly per capita consumption at all-India and state level were collated from the above rounds.

Data on trade of sorghum (exports and imports) for the period of study (1972–73 to 2004–05) is obtained from Food and Agriculture Organization of the United Nations (FAO). Three-year average of imports and exports is considered in order to even out year-to-year fluctuations.

Data on sorghum production in India is obtained from publications of Directorate of Economics and Statistics, Government of India that provides data on area, production and yield of principal crops in India on annual basis. Three-year average of area and production of sorghum is considered to even out any sharp year-to-year fluctuations.

Seed consumption demand is estimated in consultation with breeders and researchers on seed rate used for sorghum for the past three decades. Accordingly, the seed rate is multiplied with the area under sorghum during the period of study to estimate seed demand. Wastage is assumed to be 0.01% of the total supply for the reference period.

Population data for urban and rural areas in India for the period 1971, 1981, 1991 and 2001 are obtained from publications of Census of India (Registrar General and Census Commission of India, Government of India, New Delhi). Population is projected for the respective reference period under study based on the census population and growth rates. After obtaining the population for the period of study, it is bifurcated into rural and urban population based on the percentage of rural and urban population prevailing during respective census periods.

To obtain the annual consumption demand of sorghum in India for the entire population for the reference period, the all-India monthly per capita consumption of sorghum in rural and urban areas is multiplied with total all-India rural and urban population respectively. The monthly rural and urban consumption of sorghum is then multiplied by 12 to get per annum consumption of sorghum.

After accounting for utilization of sorghum for food consumption, seed demand, wastage and export, the unaccounted or the remaining supply/availability is considered as the estimate of sorghum utilization for alternative uses (Fig. 1).

Results and discussion

Sorghum production trends. There has been 44% decline in area of sorghum cultivated in India from 1972–73 to 2004–05 (16.1 to 9.0 million ha). However, during the same period production declined by 11% only from

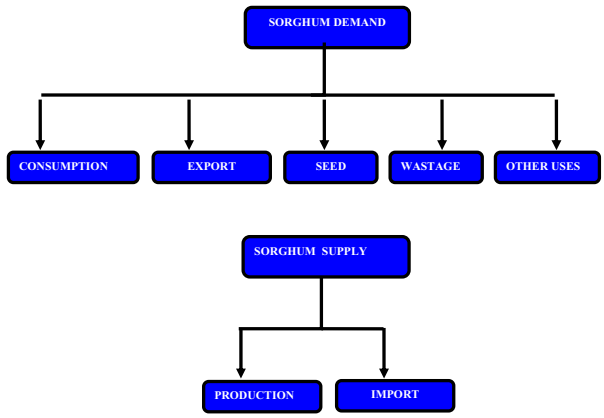

Figure 1. Flow chart of sorghum utilization and supply.

7.93 to 7.05 million tons mainly because productivity growth to some extent compensated the decline in area (Fig. 2). This was the phase when many sorghum hybrids with high yields were released in India (Reddy et al. 2006).

The overall decline in area and slow growth in relative productivity coupled with decline in real market prices of sorghum grain reduced the profitability of the crop vis-à-vis other competing crops like sunflower (*Helianthus annuus*), soybean (*Glycine max*), groundnut (*Arachis hypogaea*), etc. The Special Oilseeds Mission set up by Government of India also made oilseeds production more competitive by promoting improved seed and technology and raising import tariff to protect the domestic oilseed sector in the early 1990s. The decline in sorghum area is despite the fact that during this period real sorghum stover prices increased due to higher demand from the livestock sector to meet the growing demand for milk and meat. This was reflected in the declining grain to fodder price ratio for sorghum (Kelley et al. 1993).

For estimating sorghum production in India during the study period, three-year average figures of area and production are considered to even out year-to-year fluctuations. In India, sorghum is grown in two seasons, *kharif* and *rabi*. While area and production statistics are

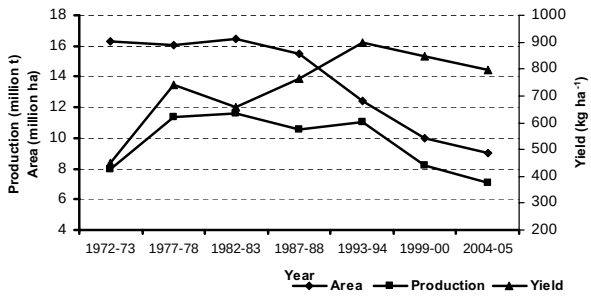

Figure 2. Area, production and yield of sorghum in India during 1972 to 2005.

available separately for *kharif* and *rabi* sorghum, consumption statistics available from NSSO are reported for all sorghum. The area and production trends of the two crops are somewhat different (Fig. 3). Area under *kharif* sorghum which accounted for 62% of the total area under sorghum during 1972–73 declined to 45% by 2004–05, while the area under *rabi* sorghum increased from 37% to 54% during the same period. However, the share of *kharif* sorghum production in total sorghum production declined less drastically from 70% of total production in 1972–73 to 60% in 2004–05 because yield increase in *kharif* sorghum was higher than that in *rabi* sorghum. The higher yield in *kharif* sorghum is attributed to use of hybrids and improved cultivars grown under improved production technology. A similar breakthrough in *rabi* sorghum was not achieved since the *rabi* crop is grown on residual soil moisture and suitable improved cultivars were not available. However, sorghum produced during *rabi* is preferred for food consumption because of the good quality and taste of grains and for its fodder which is considered to be more palatable.

Consumption trends. Between 1972–73 and 2004–05, the annual per capita consumption of sorghum at all-India level has declined sharply by 68% (8.5 to 2.7 kg) in urban areas and by 70% (19.1 to 5.2 kg) in rural areas of India (Fig. 4). This decline in per capita consumption of sorghum both in rural and urban areas at all-India level is due to several factors but the most important ones are increase in per capita income, growing urbanization, changing tastes and preferences (Chand 2007). Such a decline in consumption trend is also seen for the cereal group as a whole in general and coarse cereals like sorghum and pearl millet (*Pennisetum glaucum*) in particular. While these trends are universal, ie, affecting sorghum consumption as food in all Asian countries, an important factor more relevant to India is government policy related to rice and wheat.

As a food security strategy, the Government of India supplies subsidized rice and wheat through Public Distribution System (PDS) that has contributed to the decline in consumption of sorghum and other cereals like pearl millet and finger millet (*Eleusine coracana*) even in remote rural areas and urban centers. A closer scrutiny of trends reveals that although the consumption of sorghum at all-India level has declined in the past two decades, both in rural and urban areas, the decline is seen to plateau since the late 1990s. Sorghum consumption is expected to continue at these lower levels owing to its decrease as a staple in the major growing states.

Despite the decline in per capita consumption, sorghum grain is an important staple for the low and middle income consumers (Table 1). The low income consumers (about 30% of population in rural and urban areas each) account for 35% and 49% of sorghum consumption in rural and urban areas of India respectively. Their per capita consumption is also the highest among the three income groups. The share of high income consumers is low both in rural and particularly urban India.

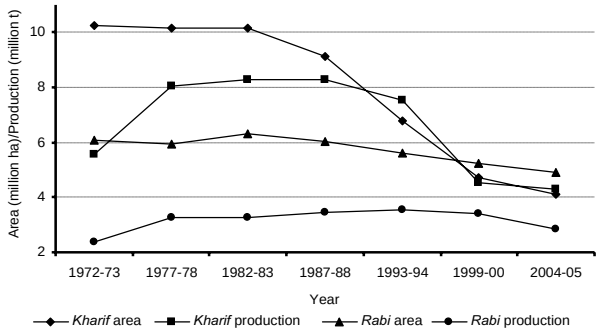

Figure 3. Trends in *kharif* and *rabi* sorghum area and production in India.

Table 1. Consumption of sorghum in India by income class[1].

Expenditure category	Consumption ('000 t)	Consumption (%)	Per capita consumption (kg yr^{-1})	Population (%)
Rural average consumption				
Low (less than ₹ 365 per month)	1421.4	35.3	6.09	30.2
Medium (₹ 365–890 per month)	2346.4	58.2	5.09	59.8
High (greater than ₹ 890 per month)	263.7	6.5	3.42	10.0
Urban average consumption				
Low (less than ₹ 580 per month)	416.4	49.3	4.46	30.2
Medium (₹ 580–1880 per month)	404.6	47.9	2.19	59.8
High (greater than ₹ 1880 per month)	24.4	2.9	0.79	10.0

1. Source: Compiled from "Level and pattern of consumer expenditure", NSSO 61st Round, 2004–05.

By and large food consumption of sorghum exhibits a declining trend across all the major sorghum producing/consuming states both in rural and urban India, but the decline is variable across states (Figs. 5 and 6). The largest decline in consumption is seen for the states of Andhra Pradesh and Madhya Pradesh both in rural and urban areas (Table 2). Though these states were important sorghum consuming states during 1970s and 1980s, the availability of cheaper staples such as rice in Andhra Pradesh and wheat in Madhya Pradesh has contributed to the increased substitution of sorghum.

In the states of Maharashtra and Karnataka, where sorghum had a major share in consumption basket in these states during 1970s, it is still able to compete in the cereal consumption basket because of existence of strong preference of sorghum in the daily food requirement in the major growing regions of these states. The findings presented in Table 3 show that in rural Maharashtra, sorghum which had a major consumption share of 46% of the total cereals consumed during 1972–73 had declined to 27% during 2004–05. Despite this, sorghum still is an important staple along with wheat and rice. A similar pattern is observed in case of rural Karnataka where despite the decline in sorghum consumption it is the second most important staple next to rice (finger millet and pearl millet are other important cereals in the consumption basket here).

In case of urban Maharashtra, the decline in consumption share of sorghum in total cereals from 20% during 1972–73 to 10% during 2004–05 is directly related to the increase in consumption of rice, whose share increased from 18% to 36% during the same period (Table 3). Similarly in urban Karnataka, the share of wheat in the total cereal basket increased from 10% during 1972–73 to 18% during 2004–05 while sorghum share declined from 24 to 12% over the same period. Rice and wheat are preferred in urban areas because of time constraint for cooking sorghum and ease of preparation of diversified products from rice and wheat.

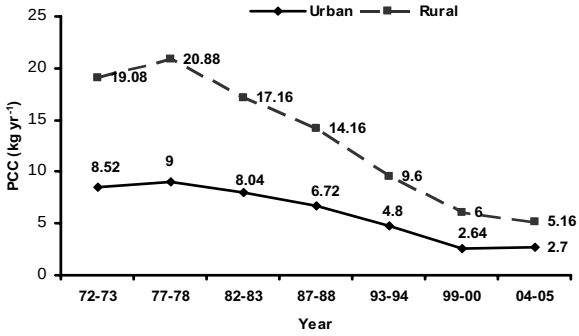

Figure 4. Trends in the annual per capita consumption (PCC) of sorghum in rural and urban India during 1972 to 2005.

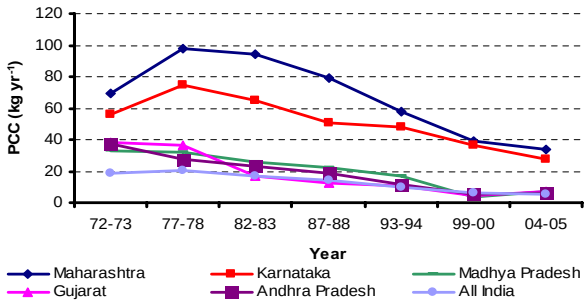

Figure 5. Annual per capita consumption (PCC) of sorghum across states in rural India during 1972 to 2005.

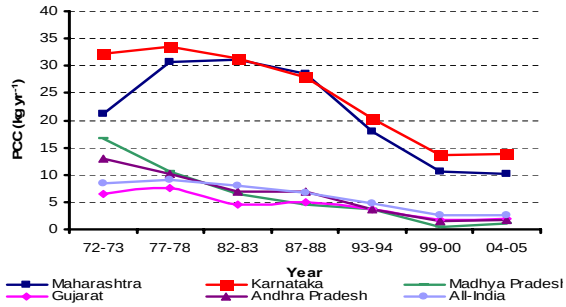

Figure 6. Annual per capita consumption (PCC) of sorghum across states in urban India during 1972 to 2005.

Table 2. Shift in per capita consumption (kg yr^{-1}) of sorghum between 1972–73 and 2004–05 across major sorghum consuming states in rural and urban India[1].

	Urban			Rural		
State	1972–73	2004–05	Percent change	1972–73	2004–05	Percent change
Maharashtra	21	10	–52	69	34	–51
Karnataka	32	14	–57	56	28	–51
Gujarat	6.5	2	–71	27	7	–73
Madhya Pradesh	17	1	–94	33	7	–78
Andhra Pradesh	13	2	–87	37	6	–84
All-India	0.71	0.2	–68	1.59	0.43	–73

1. Source: Computed from "Level and pattern of consumer expenditure", NSSO 27th and 61st Rounds.

Export demand. Only small quantities of sorghum are imported or exported from India. The export demand mainly stems from the feed industry in developing countries. During 1972–73 India imported 396,000 tons of sorghum, mainly due to drought prevailing during the period. After the 1990s, India has more or less stopped importing sorghum. However, India's export surged during 1993–94 due to good sorghum production. The demand for sorghum in the importing countries is primarily for feed use, and hence only sorghum produced during rainy season is exported as the sorghum produced during postrainy season is used for domestic food consumption as this is of good quality (Kleih et al. 2000).

Seed demand. The seed demand has been estimated after consultation with breeders on the seed rate for sorghum cultivation over the years. Based on their estimation, seed demand for cultivation of sorghum over the years has shown a continuous declining trend. Seed rate which was estimated to be 10 kg per ha during 1970s declined to 9 kg per ha during 1980s and 1990s and 8 kg per ha during the recent years.

One of the factors that have contributed to the decline in seed rate is the introduction of hybrids in the 1980s, which were more vigorous than the local varieties and consequently required lower seed quantities per hectare than the traditional saved seeds. The wide adoption of sorghum hybrids was largely due to subsidies provided by various state governments for the purchase of these seeds.

Estimation of sorghum demand for industrial uses. In the early part of the study period, the 1970s and the 1980s, sorghum was utilized solely as a food crop. Only maize (*Zea mays*) and barley (*Hordeum vulgare*) among the cereals were used in non-food/industrial uses. The use of sorghum in alternative uses (other than direct food use and seed) was only 5 and 14% in 1982–83 and 1987–88 respectively (computed from this study). This was the phase when food consumption of sorghum started showing a downward trend and coinciding of the peak production during 1993–94. From 1993–94 onwards the use of sorghum in alternative/industrial uses increased to 30% or more of total production, ie, 3–3.5 million tons (Table 4 and Fig. 7). The demand for alternative uses stems mainly from animal feed (poultry and livestock), potable alcohol and processed food industry, which is still at a nascent stage. Other industrial uses though minor include starch production and in recent years, for production of ethanol. The increase in alternative uses of sorghum came about owing to a mix of socioeconomic and policy induced factors. Government policy permitting use of grain for alcohol production along with sugarcane molasses provided the necessary fillip on usage of sorghum for alcohol production (Marshland and Parthasarathy Rao 1999). The growing demand for poultry meat particularly in urban areas, in the last two decades necessitated that sorghum be an alternate cereal source since maize grain was not able to meet the requirements of the poultry industry which has been growing at 10% per annum. The trend in alternative uses, however, declined between 1999–2000 and 2003–04 which is harder to explain. The decline in production during this period due to drought could be one of the reasons as more sorghum was diverted for food use.

Usage of sorghum grain: rainy and postrainy season. Separate utilization data for *kharif* and *rabi* sorghum are not available. In this section we try to estimate the utilization for sorghum grown in the two seasons based

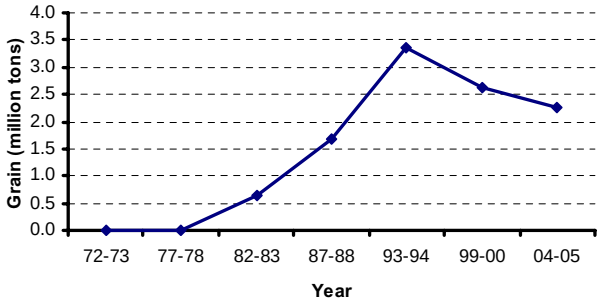

Figure 7. Trend in other uses of sorghum, 1972 to 2005.

Table 3. Share (%) of sorghum in total cereal consumption between 1972–73 and 2004–05 in Maharashtra and Karnataka[1].

	Rural				Urban			
	Maharashtra		Karnataka		Maharashtra		Karnataka	
Crop	1972–73	2004–05	1972–73	2004–05	1972–73	2004–05	1972–73	2004–05
Sorghum	46	27	30	22	20	10	24	12
Rice	16	28	29	49	18	36	52	58
Wheat	22	33	4	10	55	51	10	18

1. Source: Computed from "Level and pattern of consumer expenditure", NSSO 27th and 61st Rounds.

on expert information, field surveys and literature. Most of *rabi* sorghum grain is used for food since the grain is of superior quality and hence is preferred for consumption (bold grain, white color and sweeter taste). *Rabi* sorghum prices are higher by 20–40% compared to *kharif* sorghum grain (Fig. 8), thus making their use uneconomical in alternative uses like poultry feed, alcohol manufacture, etc in relation to other substitute cereals. Besides its use as a staple at household level, small quantities of *rabi* sorghum are used in the processed food industry (personal communication with experts and field surveys). On an average about 3–5% of *rabi* sorghum is used in the processed food industry while another 5% is used to prepare *rotis* sold at restaurants (through field surveys and consultation with processors). The decline in per capita food consumption of sorghum at the all-India level is mainly due to decline in food consumption of *kharif* sorghum while the decline was less sharp for *rabi* sorghum.

Table 5 presents estimates of percentage of *kharif* and *rabi* sorghum production used in alternative uses over the years. For *rabi* sorghum, it is assumed that in 1970s about 5% of *rabi* production was being used by the processed food industry and more recently during 2005, about 10% of the *rabi* sorghum production is assumed to be used for alternative uses like processed food, seed and *rotis* at restaurants. Accordingly, the estimates of *rabi* production available for alternative uses is obtained. Estimates obtained from *rabi* production for other uses are deducted to get *kharif* sorghum availability for alternative uses. About 8% of *kharif* production during 1982–83 was available for alternative uses while the remaining 92% was used for food consumption. Over the years, ie, from 1992–93 the *kharif* production of sorghum for alternative uses started increasing which coincided with high production during these years. The share of

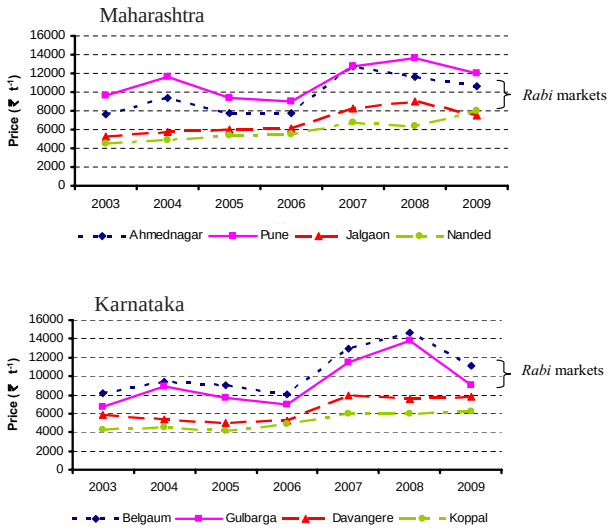

Figure 8. Trends in annual wholesale prices of *kharif* and *rabi* sorghum in Maharashtra and Karnataka, 2003–09.

consumption for alternative uses was highest during 1999–2000 at 53% and more recently in 2004–05 it was 48%. Consequently the availability of *kharif* sorghum for food use has declined while that of *rabi* sorghum has remained more or less constant (Fig. 9). Thus the declining importance of sorghum as staple food is mainly due to decline in food consumption of *kharif* sorghum.

The above estimates on usage of sorghum grown in the two seasons will help in projecting the long-term demand for sorghum for different uses in India. The assessment of potential demand from these sectors would also help breeders and other researchers to concentrate their breeding and technical efforts on specific needs of consumers and industrial users.

Table 4. Availability and utilization of sorghum in India between 1972–73 and 2004–05.

		Utilization						
Year	Availability[1] (million tons)	Consumption (million tons)	Seed (million tons)	Wastage (million tons)	Industrial uses (million tons)	Share of food consumption to availability (%)	Share of industrial uses to availability (%)	Share of seed used to availability (%)
1972–73	8.32	9.55	0.15	0.008	0	100[2]	0	2.0
1977–78	11.47	11.42	0.15	0.01	0	100[2]	0	1.3
1982–83	11.59	10.80	0.14	0.01	0.63	93	5	1.3
1987–88	11.75	9.92	0.14	0.01	1.68	84	14	1.3
1993–94	10.99	7.52	0.11	0.011	3.35	68	30	1.0
1999–2000	7.92	5.22	0.08	0.008	2.62	66	33	1.0
2004–05	7.16	4.83	0.07	0.007	2.25	67	31	1.0

1. Production + Imports – Exports.
2. The availability of sorghum was less than the demand of sorghum due to data discrepancy in consumption.

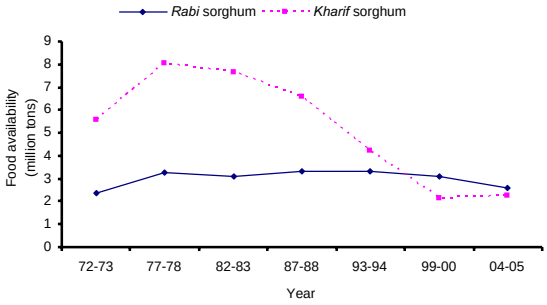

Figure 9. Trends in *kharif* and *rabi* sorghum availability for household food consumption**.**

Conclusion

The findings of the study show that while food use of sorghum has declined sharply at the all-India level, its use as food is still important in major producing states after rice and wheat although at levels 50% below that in 1972–73. The decline in per capita food consumption of sorghum, however seems to be plateauing at this lower level as indicated by data between 1999 and 2005. At the same time, the use of sorghum in alternative uses has increased from about 5% since 1993–94 to 30% or more between 1999 and 2005. Our estimates further indicate that of the total food use of sorghum, 50% is accounted for *kharif* sorghum while the rest is from *rabi* sorghum. Thus close to 50% of *kharif* sorghum goes for alternative uses. These include demand from animal feed industry mainly poultry and to some extent dairy, alcohol industry, starch industry, food processing and export demand.

With dairy sector for milk and poultry sector for meat growing at 5% and 12% per annum respectively (Parthasarathy Rao and Birthal 2008), the demand for feed from these sectors is expected to increase and that would include sorghum besides other grains. Industrial demand for grain-based alcohol is also expected to post a double digit growth rate. The recent policy of Government of India issuing 23 new licenses for distilleries producing grain-based alcohol and Maharashtra State policy of offering subsidy of ₹ 10 for every liter of alcohol produced from grain will lead to large-scale diversion of sorghum *(kharif)* for this sector and hence utilization of sorghum for alternative uses is anticipated to increase. Although the potential demand for food processing is still on a small scale, the prospects are encouraging for value addition. Here sorghum grown in *rabi* season would be preferred due to its superior grain quality. Researchers, policy makers and stakeholders should thus adopt a different strategy for *kharif* and *rabi* sorghum.

Looking at the trends of *kharif* sorghum production available for alternative uses and declining area under *kharif* sorghum, serious efforts should be made to address the problem of stagnation in area under *kharif* sorghum by targeting production to different end users like livestock and poultry feed manufacturers, alcohol sector, etc. In order to compete effectively with other close substitutes (such as maize, pearl millet and finger millet) the per unit cost of production should be brought down through high-yielding improved cultivars. This would also make the grain competitive in the export market where its demand for feed is increasing since large quantities of maize at global level are being diverted to ethanol production.

The research efforts of the breeding programs should target towards 100% substitution of sorghum with maize, pearl millet, etc in alternative uses. Studies also have reported that the sorghum grain produced during rainy season is of poor quality because of grain mold and other postharvest handling problems. This needs to be addressed to make the production of *kharif* sorghum attractive for alternative uses and for exports.

Policy makers should enable forward linkages where farmers enter directly in agreement with industrial users through contract farming, bulk marketing, etc. This will enable an assured price to the growers while the industry can expect bulk supplies of the required quality grain.

Table 5. Trends in food and alternative uses of *kharif* and *rabi* sorghum from 1972 to 2005.

Year	Sorghum production (million tons)	Availability for alternative uses (million tons)	*Kharif* production (million tons)	*Rabi* production (million tons)	*Rabi* production availability for alternative uses (million tons)	*Kharif* production availability for alternative uses (million tons)	*Kharif* production used for alternative uses (%)	*Kharif* production used for food (%)
1972–73	7.9	0	5.55	2.37	0	0	0	0
1977–78	11.34	0	8.05	3.28	0	0	0	0
1982–83	11.57	0.63	8.30	3.27	0.16	0.64	8	92
1987–88	11.75	1.68	8.28	3.47	0.17	1.70	21	79
1993–94	11.06	3.35	7.51	3.54	0.24	3.29	44	56
1999–2000	7.92	2.62	4.53	3.38	0.30	2.38	53	47
2004–05	7.18	2.25	4.32	2.86	0.28	2.08	48	52

Efforts to increase productivity in case of *rabi* sorghum would help in bringing down the prices of *rabi* sorghum and make it affordable for lower income consumers as they cannot afford to buy *rabi* sorghum due to its high price. For *rabi* sorghum, besides targeting increased yields, targeting water use efficiency, reducing drought risk and superior quality should be an overriding goal to continue its usage as a preferred staple in the crop growing area and also other regions. Incentives should be provided to food industry to use *rabi* sorghum for novel processed food products (snacks, bread, biscuits, flakes, *papad, rava,* etc) and also traditional processed products. Thus research in understanding consumer preferences and profiling utilization needs of sorghum will help in targeting the segments for better penetration. Fodder quantity and quality should also be kept in mind while improving grain quality since sorghum would continue to be a dual-purpose crop.

The research efforts in these directions will also have a ripple effect on the improvement in livelihoods of dryland farmers in marginal areas who are dependent on cultivation of crops like sorghum. Hence, keeping in view the potential demand for sorghum from these sectors, the prospects of sorghum usage and production are encouraging.

Acknowledgments. This research work was carried out under "HOPE" project. The funding support from Bill & Melinda Gates Foundation (BMGF) is greatly acknowledged.

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