Enabling Markets, Trade and Policies for Enhancing Sorghum Uptake

Parthasarathy Rao Pingali, Kumara Charyulu Deevi, and P. S. Birthal

Contents

P. R. Pingali (✉)
Formerly, International Crops Research Institute for Semi Arid Tropics (ICRISAT), Patancheru, Telangana, India
e-mail: p.partha@cgiar.org

K. C. Deevi
Research Program-Innovation Systems for the Drylands, ICRISAT, Patancheru, Telangana, India
e-mail: d.kumaracharyulu@cgiar.org

P. S. Birthal
National Institute of Agricultural Economics and Policy Research (NIAP), ICAR-Indian Agricultural Research Institute, New Delhi, India
e-mail: ps.birthal@icar.gov.in

V. A Tonapi et al. (eds.), *Sorghum in the 21st Century: Food – Fodder – Feed – Fuel for a Rapidly Changing World*, https://doi.org/10.1007/978-981-15-8249-3_2

Abstract

A number of dynamic changes are taking place in the sorghum economies globally in the last two to three decades both in developed and developing regions where the crop is grown. In Asia, its use as a staple food crop is declining with a shift in consumption towards rice and wheat. Rising per capita incomes, urbanization, change in tastes and preferences are driving this change. However, at the same time, its demand in alternative uses like poultry feed and potable alcohol manufacture is growing. In recent years driven by the greater awareness of the health benefits of sorghum, there is also a growing demand for processed sorghum products particularly in India for ready to use and eat food products mainly in urban areas (from a low base). To sustain the change in the sorghum economies (plate to plough), there is a need to reorient the marketing system by linking farmers to the end users through innovative institutional arrangements. Policies should ensure sorghum competitiveness on farm and directly or indirectly promote its use in food processing and alternative non-food uses.

In developed countries and in Latin American countries, sorghum is mainly used as feed but its use is fluctuating and variable depending on its price competitiveness and policies related to trade in feed crops. In the last one to two decades with governments mandating use of renewable fuels for blending with gasoline, sorghum along with maize are being used for ethanol production that has implications for the livestock sector. Policies related to ethanol production will have implication for sorghum production and trade.

Keywords

Sorghum utilization · Trade · Marketing · Value-addition · Policies

1 Introduction

Sorghum (*Sorghum bicolor (L.) Moench*) is the fifth largest produced cereal crop in the world and one of the staples of the world's poorest, particularly in the developing countries of Africa and South Asia (FAOSTAT 2018). In these regions, sorghum is mainly grown by small-scale farmers under rainfed conditions (Srivastava et al. 2010). Variable rainfall increases the income risk that sorghum producers face, as a result of which they tend to underinvest in fertilizers or seed of improved varieties (Parthasarathy Rao et al. 2004; Rao and Kumara Charyulu 2007). Sorghum grain and stover are of economic value—the grain is used as food, while its stover is an important dry fodder resource for large ruminants. In India, for example, the stover value accounts for nearly 30–40% of the total value of the crop (Parthasarathy Rao and Hall 2003; Parthasarathy Rao and Birthal 2008; Kumara Charyulu et al. 2016). However, a number of dynamic changes are taking place in the sorghum economies in developing countries in the last two to three decades driven by changing patterns of its grain utilization from food use to non-food alternative uses as poultry and cattle feed, manufacture of potable alcohol and ethanol.

Sorghum is also grown in developed countries particularly in the USA and more recently in Australia where it is mainly used as feed grain or exported as feed grain in the global market. Sorghum grain in the last decade or so is finding niches in the ethanol industry (USDA 2017a, b). Thus, both in developed and developing countries price competitiveness of sorghum vis-a-vis substitutes like maize, marketing, trade and policies related to cereal crops, besides technology, will drive the sorghum economies in the near future (Bhagavatula et al. 2013; Orr et al. 2016).

The focus of this paper will be on sorghum trade, prices, markets/institutions and policies that promote or hinder uptake of sorghum crop. To get a holistic picture of the crop from production to its end use, in the first few sections we will briefly look at the trends in sorghum area, production and utilization patterns. The last section will provide summary and conclusions of the key findings.

2 Sorghum Area, Production and Yield

2.1 Distribution of Area and Production

Bulk of the global sorghum crop is grown in developing countries (92%). Among the developing country regions Africa accounts for 65% of the global sorghum area and 43% of global production followed by Asia (17% area and 13.5% production) and Latin America (10 and 20%) (FAOSTAT 2018). The bulk of the crop in Africa is grown on marginal lands under low input conditions and, consequently, yield levels are relatively low (Orr et al. 2016). In contrast, yield levels are high in Latin America due to more intensive cultivation practices like in developed countries (Table 1).

Developed countries with only 8.6% of global sorghum area produce 24% of global production since the yield levels are about two to three times higher than the global average yield of 1500 kg/ha (FAOSTAT 2018). Intensive cultivation of sorghum with high input usage is the mainstay for sorghum production in North America, Oceania and Europe (Table 1). As per the latest FAO data (FAOSTAT 2020) in 2018 sorghum production was 59.3 million t down from 66.0 million t in 2014–2016, mainly due to decline in yields in the developed country regions. The share of developed countries in sorghum area declined to 6.6% and to 19.5% for production. Among the developing countries, the share of Africa increased significantly both for area and production.

Although sorghum is produced across several countries, the top 10 countries account for 76% of global area and production (Table 2). The USA is the largest producer while Sudan has the highest area. Among the top 10 sorghum growing countries, based on share in global area, seven countries are in Africa, but for the top 10 countries based on production share, only 3 countries are in Africa, followed by 3 in LAC, 2 in Asia and 2 in developed countries.

Sorghum yields are close to 4.5 t/ha in the USA and China., Argentina and Mexico (3.5 t/ha), Brazil and Australia (2.8 t/ha). For Africa yield levels are >1 t

Table 1 Region-wise share in sorghum area and production

Region	Area share (% in global area)			Production share (% in global production)			Yield (ton/ha)		
	1980–1982	1994–1996	2014–2016	1980–1982	1994–1996	2014–2016	1980–1982	1994–1996	2014–2016
Africa	30.6	50.9	65.2	19.3	30.0	42.9	0.93	0.82	0.99
North America	12.0	8.8	6.3	29.2	25.9	19.3	3.56	4.12	4.64
LAC	10.1	7.2	9.0	19.8	14.4	19.6	2.85	2.76	3.28
Asia	45.2	31.3	17.2	28.8	26.6	13.5	0.93	1.19	1.19
Europe	0.6	0.3	0.9	1.1	1.0	1.9	2.69	4.36	3.28
Oceania	1.4	1.5	1.4	1.7	2.1	2.7	1.88	2.02	2.96
World (area 000 ha; production 000 tons)	45,170	44,454	43,691	66,376	71,570	66,031	1.47	1.40	1.51

Table 2 Top 10 sorghum growing and producing countries

Country	Area share (% in global area)	Country	Production share (% in global production)
Sudan	17.3	United States of America	19.4
India	13.4	Nigeria	10.5
Nigeria	13.3	Mexico	9.4
Niger	8.1	Sudan	7.8
United States of America	6.3	India	7.8
Ethiopia	4.3	Ethiopia	7.0
Mexico	4.0	Argentina	4.8
Burkina Faso	3.5	China, mainland	4.1
Mali	3.2	Brazil	2.8
Chad	2.6	Australia	2.7

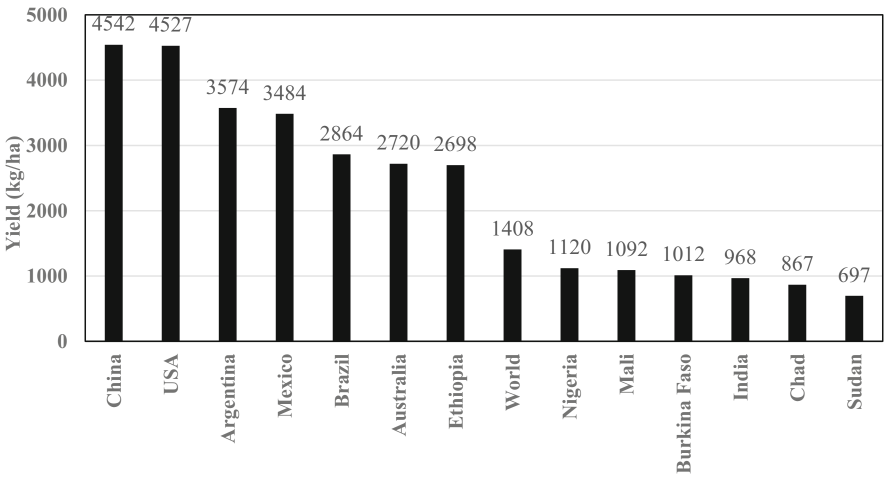

Fig. 1 Sorghum yield in selected countries, 2018

per ha in Ethiopia, Nigeria and Mali; and <1 t per ha in Chad and Sudan (Fig. 1) Yields are closer to the global average (1.5 t/ha) in Asia as improved seeds and fertilizers are used, though area has been falling as farmers shift to other, more remunerative crops. Furthermore, there is a large disparity in yield levels within Asia in the major sorghum-growing countries with yields in China nearly four times those in India and Pakistan.

Table 3 Annual growth rates in sorghum area, production and yield (percent / annum)

	Area		Production		Yield	
Region	1980–1996	1997–2016	1980–1996	1997–2016	1980–1996	1997–2016
Africa	3.4	1.3	2.6	2.1	−0.8	0.8
North America	−2.6	−2.1	−1.5	−1.8	1.1	0.3
LAC	−3.3	0.4	−3.3	1.2	0.0	0.8
Asia	−2.8	−3.1	−1.0	−1.9	1.8	1.2
Europe	−4.5	5.2	−0.3	3.3	4.2	−1.9
Oceania	−1.3	−0.1	−0.7	1.2	0.6	1.3
World	−0.3	0.0	−0.7	0.5	−0.4	0.5

2.2 Historical Trends in Area and Production

Global sorghum production declined between 1980 and 1996 (−0.7%/annum) but increased marginally by 0.5%/annum since then (Table 3). Thus on average production remained at 66 million t during 1980–1982 and 2014–2016. Production trends between 1997 and 2016 indicate a growing trend in Africa, and Europe (from a low base) and Oceania. In contrast, production declined sharply in North America and Asia. Overall, the developed countries share in global sorghum production declined from 32% in early 1980s to 24% in 2016 mainly due to decline in production in the USA. Their share further declined to 19.5% in 2018 (FAOSTAT 2020).

For developing countries their global share in sorghum production increased from 68% in 1980 to 76% by 2016 mainly due to a doubling of production in Africa from 12 million t in 1980–1982 to 28 million t in 2014–2016. In 2018, Africa's production further increased to 29.7 (FAOSTAT 2020). Area expansion was the main driver during 1980–1996 (3.4%/annum) while during 1997–2016 a combination of area and productivity increase (1.3 and 0.8/annum respectively) contributed to the production growth of 2.1%/annum. In Latin America, production declined from 13 million t in 1980–1982 to 10.3 million t in 1994–1996 but recovered since then and was again at 13 million t in 2014–2016. Yield growth of 0.8%/annum contributed to the increase in production even as its area growth remained stagnant.

In contrast, sorghum area and production decreased in Asia despite yield growth of >1.2%/annum between 1997 and 2016. The region is dominated by the trends prevailing in China where the average yield levels were the second highest in the world at 4.5 t ha^{-1} in 2016. Thus, China accounted for nearly 3.6% of global sorghum production despite accounting only for 1% of global area.

Much of the area decline in Asia can be attributed to sharp decline in sorghum area in India. Decline in food demand for sorghum and policies favouring production and consumption of fine cereals were the main reasons. Also, area from sorghum cultivation was diverted since the 1980s to oilseeds such as sunflower and soybeans and cash crops such as cotton that were more profitable due to higher yields and prices driven by growing consumer demand (Nagaraj et al. 2012; Bhagavatula et al. 2013).

3 Utilization

3.1 Food Use

Sorghum has been used as a food and feed crop for centuries all over the world. In the early 1980s, 37% of sorghum grain was used as food globally but increased to 40% in 2015–2017 (Table 4). Globally, however, the per capita availability of sorghum for food use has declined from 5.3 kg/capita/annum to 3.3 in 2017 (FAOSTAT 2020). In most African countries where sorghum is grown, food use accounts for more than 60% of total domestic production (78% in Nigeria and Sudan, 61% in Ethiopia). As a close substitute of teff, consumption of sorghum in Ethiopia declines when teff prices decline and vice versa (Demeke and Di Marcantonio 2013). The per capita availability of sorghum is also highest in Africa at 16.7 kg/capita/annum in 2016 and has remained stable over the years despite population growth (Orr et al. 2016). The per capita consumption of sorghum has increased in areas affected by adverse climatic conditions which favour the production of sorghum instead of other cereals.

In Asia, food use of sorghum has declined driven by increases in income, urbanization and changing consumer preferences. In India, sorghum is a traditional cereal staple but its use has been declining over time, particularly in urban areas (Basavaraj and Parthasarathy Rao 2012). Per capita availability for food declined in India from 13.9 kg/capita/annum to 3.6 kg/capita/annum (GOI 2016). In India, sorghum is grown in two seasons, rainy and post-rainy season. Post-rainy season sorghum grain prices are higher by 20–30% compared to rainy season sorghum, due to its superior grain quality with bold grain, lustrous white colour and sweeter taste and hence is mainly used for food. In contrast, bulk of the rainy season sorghum is finding its way for alternative non-food uses (Marsland and Parthasarathy Rao 1999;

Table 4 Global trends in utilization of sorghum for different uses

	Production/supply (000 t)			Share in production/supply (%)		
Uses	1980–1982	1994–1996	2015–2017	1980–1982	1994–1996	2015–2017
Feed	35,332	31,390	28,455	55.4	50.3	45.3
Food	23,371	25,069	24,888	36.6	40.2	39.6
Other uses	32	53	2196	0.1	0.1	3.5
Processing	1251	1957	3452	2.0	3.1	5.5
Seed	894	912	996	1.4	1.5	1.6
Waste	2947	2986	2890	4.6	4.8	4.6
All uses	63,827	62,367	62,877	100.0	100.0	100.0

Kumara Charyulu et al. 2014). During the last decade there is growing ‘new market’ for coarse grains among ‘health conscious’ urban Indian consumers. Sorghum and millet are rich in micronutrients Fe and Zn, dietary fibre, antioxidant nutrients and starch and also one of the cheapest sources of these nutrients (Parthasarathy Rao et al. 2006). Small quantities of sorghum are being used by the food manufacturing industry for making flakes, *rawa*, biscuits, breads, noodles and cakes. The demand for such products is increasing from a low base with growing awareness of the nutritional value of sorghum grain (Basavaraj et al. 2014).

China is another important sorghum growing country where its food use declined sharply. Per capita consumption of sorghum declined steadily from 4.4 kg capita^{-1} in 1980–1982 to 1.3 kg in 2016. However, it continues to be consumed in the rural semi-arid and arid regions as porridge, substituting for rice.

3.2 Feed Use

The demand for sorghum grain as feed is concentrated in the developed countries and the middle-income countries of Latin America and Asia (USA, Mexico, Japan, China, etc.) where the demand for livestock products is relatively high. For example in 2015–2017, feed use accounted for 58% in the USA, 97% in Mexico and 79% in China (Table 5). As animal feed, sorghum grain is considered to be a close substitute for maize, and sorghum feed grain prices generally track those of maize very closely. Sorghum provides nearly the same metabolizable energy as maize, is rich in niacin, and has higher crude protein content than maize (ICRISAT 1996).

In Asia, Japan and China are the main consumers of sorghum grain for feed. In Japan, where there is a preference for white meat, sorghum is an important ingredient in compound feed rations for poultry, pork and some beef cattle. In India, sorghum grain is used as poultry feed and is generally substituted to the extent of 10–25% of maize if its price is 10–15% lower than maize price (survey data under the project (2008–2013) on promoting sorghum for poultry feed). The quantities involved are still small. However, FAO database has not fully factored in the growing feed use of sorghum in India. We surmise that some of the grain quantity shown under ‘waste/ losses’ category would actually be for feed use.

In Africa, the use of sorghum as animal feed is limited. However, in countries like Ethiopia in recent years with the gradual emergence of cattle fattening and poultry operations, corn has started to be used in greater quantities in livestock feed. Feed experimental studies conducted in Ethiopia also proved that the substitution of corn with sorghum up to 45% appear to be biologically better and not having any adverse effect on broiler performance (Mohamed et al. 2015).

3.3 Other Uses

In Africa, sorghum beer is an important cottage industry. Sorghum beer is popular as it provides a cheaper alternative to barley-based beverages in these countries. In

Table 5 Utilization of sorghum in major growing countries (percent of domestic supply) 2015–2017

Uses	USA	Mexico	Nigeria	Ethiopia	India	Argentina	China	Sudan
Feed	2869 (58)[a]	5926 (97)	363 (5)	608 (13)	46 (1)	2139 (97)	8345 (79)	534 (13)
Food	214 (4)	0 (0)	6148 (86)	2407 (50)	4334 (89)	0 (0)	2063 (19)	2648 (65)
Other uses	0 (0)	0 (0)	0 (0)	1482 (31)	0 (0)	0 (0)	14 (0)	470 (12)
Processing	1656 (34)	0 (0)	172 (2)	0 (0)	0 (0)	0 (0)	0 (0)	113 (3)
Seed	19 (0)	23 (0)	116 (2)	79 (2)	181 (4)	12 (1)	59 (1)	87 (2)
Waste/losses	163[b] (3)	148 (2)	383 (5)	256 (5)	285 (6)	58 (2)	134 (1)	195 (5)
Domestic supply (000 t)	4921 (100)	6097 (100)	7181 (100)	4832 (100)	4846 (100)	2209 (100)	10,615 (100)	4048 (100)

[a] Figures in parenthesis indicate percent share in domestic supply
[b] In the USA, the figure refers to residuals

Asia, the use of sorghum in alcohol production is most popular in China to make beverages such as *kaoliang* and *mao-tai.* In India, the use of sorghum grain in making commercial grade alcohol is increasing in popularity with the lifting of the ban on the use of food grains for the manufacture of alcohol, used for potable liquor and other industrial uses (Dayakar Rao et al. 2003).

4 International Trade in Sorghum

On an average about 16% of sorghum was traded in 2016 relative to its production compared to 20% in 1980 (FAOSTAT 2018). Export volumes too fell from 13 million t in the early 1980s to 6.9 million t by 1994–1996 but jumped to 10.4 million t in 2014–2016 owing to sudden spurt in import demand from China. Global exports were as high as 13.2 million t in 2015 and then declined to 8.7 million t in 2016 and further to 7.2 million t in 2017. This is mainly due to the tapering down of import demand from China. In contrast, exports of maize spurted and nearly doubled from 80 million t in 1980 to 147 million t in 2016 (Fig. 2).

Sorghum exports are dominated by five countries in 2014–2016 that account for 96% of global sorghum exports, with the USA accounting for 76% of the exports followed by Australia, Argentina, Ukrine, and France (Table 6). Similarly, for imports five countries account for 87% of global sorghum imports with China accounting for 74% of global imports followed by Japan (7.5%), Mexico (3.1%) and Ethiopia and Sudan 1% each. China became a major importer only from 2014. If we consider 2011–2013 average data China's sorghum imports were only 7% of global imports. Mexico and Japan were the main importers accounting for nearly 50% of global sorghum imports.

Global trade in sorghum grain is mainly to meet demand for livestock feed, primarily Japan (for poultry feed) and Latin America. For livestock feed sorghum

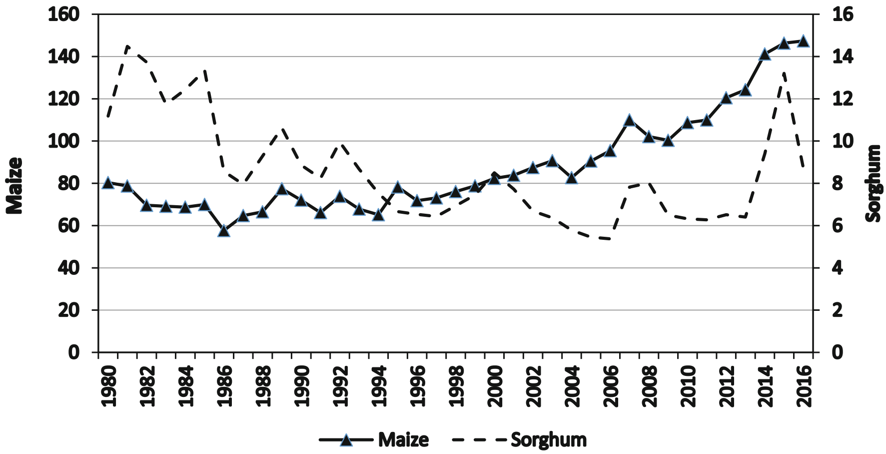

Fig. 2 Trends in global export of maize and sorghum (million tons)

Table 6 Top five sorghum export and importing countries

Country	2014–2016 Quantity (000 tons)	2014–2016 Share in global exports (%)	Country	2014–2016 Quantity (000 tons)	2014–2016 Share in global imports (%)
United States of America	7971.7	76.3	China	7707.4	73.9
Australia	897.2	8.6	Japan	780.7	7.5
Argentina	895.1	8.6	Mexico	318.2	3.1
Ukraine	143.2	1.4	Ethiopia	146.0	1.4
France	142.6	1.4	Sudan	139.0	1.3
World (share of top five countries)	10,441.4	96.3	**World (share of top five countries)**	10,429.4	87.2

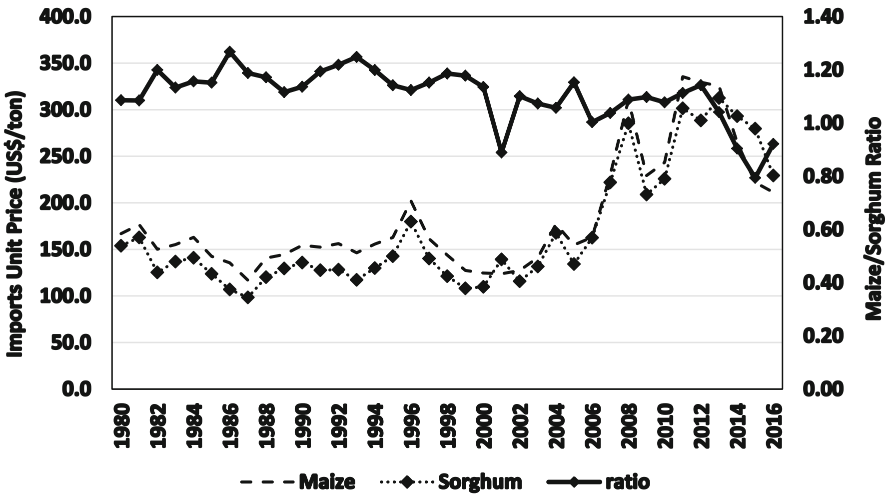

Fig. 3 Trends in global average unit prices of maize and sorghum

has to compete with maize which is a preferred feed grain. Sorghum is substituted partially for maize only when its price is below maize price. Thus sorghum trade is sensitive to sorghum-maize price differentials. The price of sorghum tracks the price of maize and is, on an average, lower than that of maize price by 5–10% (Fig. 3). Between 1980 and 2000 the maize to sorghum price ratio was >1 and thereafter it came down though still above 1 or close to 1, and declined to around 0.8 in 2015. As the maize to sorghum price ratio came down since 2001, maize exports increase at a fast pace as sorghum prices became uncompetitive compared to maize. Sorghum exports spurted in 2014 and 2015 mainly due to the surge in import demand from China. This has however started reversing to some extent since 2016 (Fig. 4).

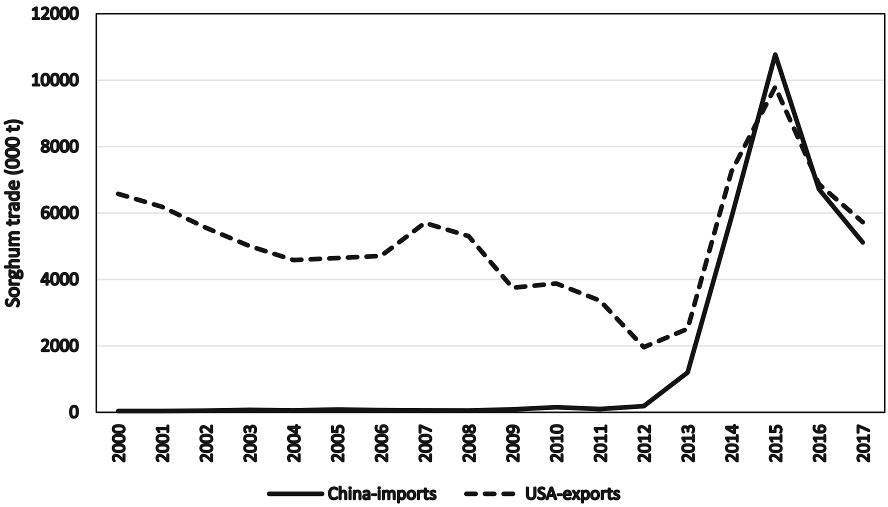

Fig. 4 Trends in sorghum exports from USA and imports to China

4.1 Exports

North America is the largest exporter of sorghum and has dominated the international trade market since the early 1980s. In 2014–2016 it accounted for 77% of global sorghum exports (Table 7). However, exported volumes fell from 7 million t in 1980–1982 to 5.4 million t in 1994–1996. The reduction in export volumes was a result of the sharp cutback in sorghum production in the USA in the late 1980s to early 1990s owing to agricultural policies that favoured maize production over sorghum. However, in 2014–2016 export volumes spurted to 8 million t driven by the large import demand from China.

Latin America is the second largest exporter of sorghum, but the exported volumes have reduced drastically and are reflected in its global share of exports that came down from 30.4% in 1980–1982 to 9% in 2014–2016 (and further to 6.6% in 2017). The export volumes of Argentina, the main exporting country in the region, came down from 3 million t in 1980–1982 to 0.51 million t in 2016. The lifting of import restrictions on maize in various Latin American countries such as Mexico, Colombia and Venezuela and in the former USSR resulted in export volumes declining (USDA 2017c). Oceania/Australia is another important exporter of sorghum, exporting 0.9 million t, i.e., about 9% of global exports in 2014–2016 compared to 6% in 1980–1982. However, its share has come down to 4% in 2017 (FAOSTAT 2020).

Table 7 Trends in region-wise exports and imports of sorghum

Region	Exports (% to world)			Imports (% to world)			Net trade (000 t)		
	1980–1982	1994–1996	2014–2016	1980–1982	1994–1996	2014–2016	1980–1982	1994–1996	2014–2016
Africa	3.5	3.9	1.1	1.4	4.8	8.1	283	(−66)	(−736)
North America	56.2	78.6	76.6	0.0	0.1	0.5	7377	5429	7952
LAC	30.4	7.0	9.2	25.4	38.5	4.9	753	(−2198)	448
Asia	2.1	2.9	1.0	40.0	43.0	83.4	(−4838)	(−2793)	(−8586)
Europe	1.9	3.4	3.5	33.3	11.8	3.0	(−4000)	(−584)	59
Oceania	5.9	4.3	8.6	0.1	1.9	0.2	761	162	876
World (000 t)	13,129	6909	10,441	12,793	6959	10,429	–	–	–

4.2 Imports

For imports, Asia has been, and continues to be, the largest importer (Table 7). Imports are mainly to Japan where sorghum is a preferred feed ingredient in the poultry and pork industry. However, the volumes have been declining from 3.6 million t in 1980–1982 to 0.78 million t in 2014–2016.

Since 2014, however, there has been a dramatic increase in imports to Asia with imports to China increasing from 0.18 million t in 2012 to 5.8 in 2014, 10.8 in 2015 and 6.71 in 2016, i.e., an average of 7.8 million t during 2014–2016. Consequently, Asia accounted for 83% of global imports of sorghum in 2014–2016 compared to 40% in 1980–1982. The bulk of the imports to China came from the USA since they have lower tannin content and are more suitable as feed (Fig. 4). However, the imports to China are on a declining trend since 2016 and projected to decline further in 2017 (USDA 2017d). As per latest available FAOSTAT (2020) data imports to China were 5.1 million t in 2017 indicating a further decline since 2016.

China's agriculture and trade policies in the corn sector are driving much of the growth in sorghum demand and imports. China introduced a temporary reserve program for corn in 2007 and a price support policy in 2011. Under this program both corn production and price increased as the government purchased corn for storage and stocking. At the same time, it imposed tariff rate quotas on corn imports. Due to higher domestic corn price and costlier imports, the use of cheaper substitutes like sorghum started to increase. In 2015 China's imports accounted for 80% of the world total sorghum imports. In 2016, China terminated its temporary reserve program for corn and price support policy. Instead it implemented a direct payment subsidy policy towards corn which is tied to corn planting. This led to lower corn prices (Wang 2017). US sorghum is gradually losing its price advantage to Chinese domestic corn. Consequently, sorghum imports started to decline from 2016. It declined by 33% compared to 2015 and this trend is projected to continue (USDA 2017d).

LAC was the second highest importer in 1980–1982 with 25% share in global imports that increased to 38% in the 1990s but has since come down to 5% in 2014–2016. Thus for imports to LAC, the volumes have declined from 3.2 million t in 1980 to 0.5 million t in 2016. This is largely due to decline in imports to Mexico which was the largest importer in the region. This might be due to increase in domestic sorghum production over time due to increasing domestic demand.

In the early 1980s Africa had a small export surplus, but the region turned into a net importer accounting for 8% of global imports with Sudan and Ethiopia accounting for the bulk of these imports, probably as food aid (USDA 2017e). Its share in imports further increased to 11.3% in 2017 (FAOSTAT 2020). In Africa, there is considerable informal cross-border trade in sorghum that is often unrecorded and is underestimated in official statistics.

Uganda is the region's biggest informal exporter of sorghum (329,000 t of informal exports in 2013). South Sudan is the region's biggest informal importer (317,000 t in 2013) (FSNWG 2014a, b). Informal sorghum imports to Kenya in 2013 were only 14,000 t. Ethiopia also exported sorghum but mostly to Eritrea, Djibouti and Somalia (Orr et al. 2016).

5 Markets and Policies

Domestic policies and institutional support play an important role in determining the prevailing trends in production, utilization and trade in agricultural commodities in the major growing countries. Over the years, sorghum as also other coarse cereals (other than maize) have been neglected on this front with policies favouring rice, wheat and maize. For example, in Africa, farmers preferred maize over sorghum, as government support measures for sorghum are relatively small compared to maize (Orr et al. 2016). In Asia, particularly in India, irrigation and fertilizer subsidies have increasingly favoured rice, wheat and cash crops at the expense of coarse grains on the production front. On the consumption side favourable procurement policies for rice and wheat and their distribution at subsidized price through public distribution system dented their consumption (Nagaraj et al. 2012; Kumara Charyulu et al. 2016). At the same time on the demand side, for example, in India, changing food preferences owing to rising income and growing urbanization are leading to a substitution of coarse grains like sorghum with fine cereals (Basavaraj and Parthasarathy Rao 2012). In China consumption of livestock products rose sharply due to urbanization.

5.1 Marketing System for Sorghum: Need for Innovation

In developed countries where sorghum and millets are grown for feed use, the value chain for sorghum is highly developed with large volumes and stringent quality standards for both domestic use and export markets. In contrast in developing countries, particularly in Africa, sorghum and millets are usually grown for domestic consumption and stored in small quantities, mostly in traditional storage containers/ structures. Only small surpluses make its way to the markets. Thus domestic markets for sorghum and millets in Africa and Asia are characterized by low and variable volumes, high transaction costs and long distances to larger markets (Marsland and Parthasarathy Rao 1999; Orr et al. 2016). Also, compared to other cereal grains, sorghum and millets are not widely traded internationally for food use and there are very few quality standards that are met. For example, in Ethiopia, the marketing of sorghum offers low financial returns due to weak and limited market opportunities. This is because of lack of connection between producer, industry and international markets. Over the last decade, formal imports and exports represented less than 1% of production (USDA 2017e). The local and international markets are disconnected owing to very low amount of sorghum traded.

In Asia, dynamic changes are taking place in the utilization pattern of sorghum with a decline in food use while its use as poultry feed and for manufacture of grain alcohol is growing. Under the changing pattern of utilization of sorghum grain there is a need for innovation in the marketing system by linking farmers to the end users. The traditional marketing system that caters to use of sorghum as food is not designed to meet the industrial demand for sorghum. Hence, innovative institutional arrangements are being piloted to promote sorghum for industrial uses involving bulk marketing through farmers' association, contract farming between farmers and end users (Parthasarathy Rao et al. 2009). Under a project on linking sorghum and millet farmers to poultry feed industry, ICRISAT pilot tested a Coalition Approach involving all stakeholders in the value chain for bulk marketing of sorghum grain for poultry feed in India, Thailand and China (Parthasarathy Rao et al. 2009). The stakeholders included both research and non-research stakeholders, i.e., sorghum research institute, seed industry, input suppliers, feed manufacturers, supply chain functionaries and sorghum farmers. The project impact was encouraging with the farmers able to find a steady market for their produce and the feed industry assured of supplies of required quantity and quality.

In China, contractual arrangements between the sorghum growers and alcohol industry are in place involving the sorghum research institute for supply of quality seeds. The alcohol industry procures seed of required quality from the sorghum research institute and supplies to the farmer with a buy back arrangement for the grain—a win-win situation for both the farmers and the industry (Ravinder Reddy et al. 2012).

5.2 Food Processing and Value Addition

While food use of sorghum grain as staple food has declined in India at the same time its demand for ready to use (RTU) food products or convenience foods is growing (albeit from a low base). Urbanization, growing numbers of working women, diversification of diets, and the growth of the middle-class are the main drivers. However, value addition in the existing value chain of sorghum is limited to physical processing involving cleaning for foreign matters and limited grading. Thus, product upgradation of the value chain through production of RTU products is an option to grow the value chain that will provide benefits across different stakeholders of the value chain including farmers (Basavaraj et al. 2014).

Against the background of growing demand for RTU products, a renewed effort has been made by the Indian Council of Agricultural Research (ICAR), to create demand for sorghum for food uses by bringing in processing interventions. Currently, IIMR (Indian Institute for Millets Research) is marketing processed sorghum products (multi-grain *atta*; vermicelli; biscuit; flake and pasta) under the brand name DSR-Eatrite (Chavan et al. 2016; Dayakar Rao et al. 2015). These products are marketed through Heritage Fresh retail outlets and Choupal Fresh (ITC) and through unorganized retail stores in Hyderabad. Under this value chain the farmers are benefited by technical support for intensive cultivation and market assurance for their produce while consumers are benefitted by the choice of sorghum products available for ensuring their nutritional security.

5.3 Policies in Sorghum-producing Countries

Policies related to cereal crops/cereals in sorghum-producing countries and their implication on sorghum production, consumption and prices are reviewed and summarized for select sorghum-producing countries.

5.3.1 India

Policies favouring fine cereals on the production and consumption end have adversely effected production and consumption of coarse cereals including sorghum. On the production side, besides subsidies on fertilizers and irrigation favouring fine cereals and other irrigated crops on the price front too, the minimum support price (MSP) announced by the government before planting of the crop was is generally low (lower than that for coarse variety of paddy). Since 2012–2013, MSP for sorghum has been rising (Fig. 5). However, unlike for paddy and wheat coarse cereals were not procured nor did the government intervene when prices fell below the MSP as the government does not have any buffer stock commitments for coarse grains. On the consumption front subsidies provided by the Government of India (GOI) for rice and wheat under the Public Distribution System (PDS) have led to the substitution of coarse cereals by the fine cereals in the consumption basket of both the rich and the poor as well as urban and rural consumers (Kumara Charyulu et al. 2016). This is rectified to some extent under the Food Security Mission with inclusion of coarse grains under the PDS. However, ground level implementation is wanting.

The GOI does not allow the use of food grains, including coarse cereals, to produce biofuels. The Indian approach to biofuels is based on non-food feedstock to deliberately avoid a possible conflict between food and fuel. However, grains certified not fit for human consumption can be used to produce potable alcohol for industrial use, including use for ethanol (Basavaraj et al. 2012; USDA 2017f).

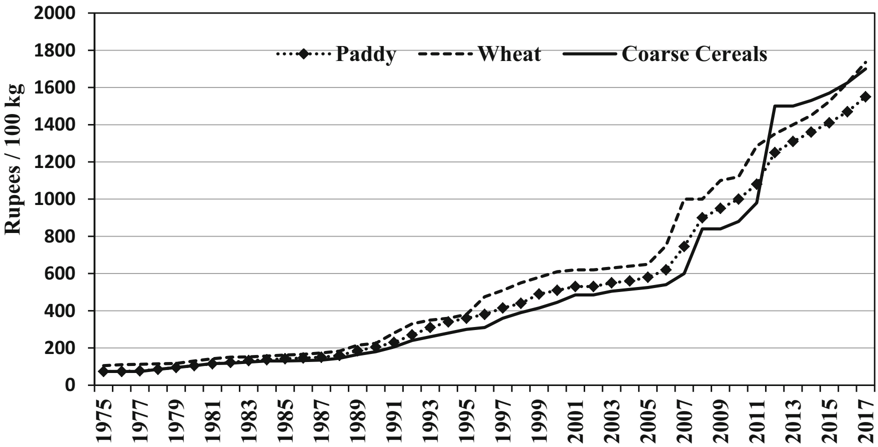

Fig. 5 Trends in minimum support prices (MSP) for selected cereals in India

5.3.2 USA

Under the 2014 Farm Bill, that cover feed grains also payments are made to producers when market prices fall below the reference market prices set in Farm Bill under Price Loss Coverage (PLC) to farms when there is a difference between per acre guarantee and actual revenues for the covered commodity[1] under Agriculture Risk Coverage (ARC).

For ethanol policy incentives underlie the interest for its production. The Energy Policy Act of 2005 established a renewable fuel standard (RFS), which mandated the use of renewable fuels in gasoline. Corn is the primary feedstuff used to produce ethanol; however, other grains (especially sorghum) are also important.

Corn used for ethanol production increased from less than 1% of total U.S. domestic corn use in 1980/1981 to about 40% of total U.S. domestic corn use by 2011/2012 (Walsh 2011). This large and rapid expansion of U.S. ethanol production affects virtually every aspect of the field crops sector, ranging from domestic demand and exports to prices and the allocation of acreage among crops. The use of grains for ethanol production has implications for the livestock sector too.[2]

5.3.3 Mexico

In 2008, Mexico opened its borders to inexpensive, subsidized U.S. grains. The imports of both corn (yellow) and sorghum have increased substantially till 2011. Each grain's international price played a central role in modifying the feed industry's grain demands. Later Mexican government has encouraged the use of white maize for animal feed by providing subsidies to companies for commercialization, transport and storage (Huacuja 2013). Research analysts stated that sorghum, corn, and eventually wheat will all continue competing with each other, in some degree, to meet Mexican feed demand, and ultimately usage will depend on the market price situation. For ethanol production in 2015, Pemex, Mexico's state-owned petroleum company, announced its plan to introduce a pilot program that would blend gasoline with ethanol. This has implications on the use of sorghum as feed stock for ethanol. This will further enhance the demand for sorghum in the country (USDA 2017g).

5.3.4 Nigeria

Sorghum production occurs mostly within the northeastern part of Nigeria where Boko Haram insurgencies continue to limit land for sorghum production. However, farmers have continued production due to increasing prices and rising sorghum demand—both for food and for industrial use. Private sector industrial consumers are also expected to increase their support to farmers through some out-grower arrangements that will support local farmers with inputs, improved seeds/seedlings, storage and processing facilities, credits, etc. (USDA 2017h).

The government attempted to introduce a Guarantee Minimum Price (GMP) for cereals including sorghum but it is barely applied because of funding and logistic

[1] https://www.ers.usda.gov/topics/crops/corn/background/

[2] https://www.ers.usda.gov/topics/crops/corn/policy/

constraints. To boost the sorghum domestic production, Agricultural Transformation Action Plan (ATAP) was started in 2011 (Gourichon 2013). ATAP focuses on improving the production in terms of quantity and quality in order to develop the brewery industry within the country.

5.3.5 Ethiopia

The sorghum value chain is long and involves too many small operators. Disincentives are substantial during normal years and arise from: (1) overvalued exchange rate, (2) export ban, (3) distribution of imported wheat at subsidized price (with negative implications for sorghum), and (4) weak market structure (and high transportation costs). Sorghum production and marketing are affected by lack of government attention and inadequate support from research, agricultural programs and rural development policies. Overall, sorghum production has increased in recent years owing to area expansion but an improved and stable policy environment is needed to enhance investment in yield-enhancing technologies (USDA 2017e).

5.3.6 Argentina

Despite improved seed technology and policy support for corn at the expense of sorghum, area under sorghum held on since it has the advantage of drought and it is excellent for crop rotation. 'Import substitution strategy' was an important plank of agricultural policies of the government. This strategy favours local production, dismisses the importance of exports and opening of the economy for improving the competitiveness. The emphasis was on increasing fiscal revenues through high tax rates imposed on agricultural products' exports, e.g., 20% on sorghum since 2002 to current. The export of primary products was taxed at a higher rate than processed products in order to promote local value addition (USDA 2017c).

5.3.7 China

As already alluded to China's agricultural and trade policies in the corn sector are driving much of the growth in sorghum demand and imports. Due to the policies related to corn production and trade, livestock producers in China not only faced higher domestic feed prices but also constraints on their ability to import corn from abroad. In response, the livestock industry has shifted its feed inputs towards low-priced sorghum, sidestepping GM restrictions and a variety of import trade barriers (Wang 2017). However, with the reversal of the policies related to corn, sorghum competitiveness is declining in the face of falling corn prices. In 2016/2017 sorghum imports are forecast to fall 500,000 tons to 4.5 million tons due to lower price competitiveness in the face of falling corn prices.

5.3.8 Australia

Government subsidies, import tariffs and capital grants fuelled proposals for new ethanol projects. As and when the new ethanol projects take off as planned, there would be a significant increase in domestic grain demand. This would raise grain prices particularly lower priced grains such as sorghum. Any increase in domestic sorghum prices would benefit grain producers but would be detrimental for other grain users such as the livestock industry (Cuevas-Cubria 2012).

The Dalby ethanol plant in Queensland has announced that it is expanding operations because of the new Queensland ethanol mandate. Currently, around 200,000 MT a year of sorghum is used for ethanol production when the Dalby operation is running at full capacity and this amount could increase in the future. The biofuel plant also produces DDG which is sold mainly as a high-protein stock feed for pigs, dairy cows and lot-fed cattle (USDA 2017b).

6 Conclusions and Way Forward

Sorghum is primarily used for feed in developed countries and its use will be largely driven by its price relative to competing substitutes like maize, wheat, etc. Hence it is pertinent to reduce the per unit production cost of sorghum by promoting high yielding improved cultivars. At the same time ensuring that policies relating to the feed sector are not biased against sorghum as it was in several countries in the past. Another area where there is potential for sorghum demand is its use in bioethanol industry. Many governments in developed countries are mandating blending of gasoline with ethanol in varying proportions. To meet these objectives, policies and subsides are being designed for promoting the biofuel industry. The growth of the bio-ethanol industry would stimulate use of grains including sorghum for ethanol production.

In developing countries with decline in food use of sorghum its use is growing in alternative non-food uses like poultry feed, alcohol manufacture, etc. (In Africa, sorghum is still an important staple crop.) Developing varieties with traits suitable for different uses should be an important priority of crop improvement programs to meet end user requirement (for example, varieties for alcohol manufacture). Industrial users of sorghum need bulk quantities of specified quality. Hence, institutional arrangements linking farmers to end users for bulk marketing, contract farming, etc. would ensure an assured price and market for the growers and assured supplies for the end users. A number of models for linking farmers to markets have been tried and lessons learnt. However, sustainability of these models after completion of the project and scaling up for wider coverage is a big challenge. Here, policies for promoting institutional arrangements can provide the necessary stimulus for scaling up and scaling out the linkages. These could include registration of farmers associations/producer companies with defined by-laws, pledge financing and finance against warehouse receipts, assured market/by back options, and capacity building of small-scale farmers association in price negotiation and bargaining skills to get a fair share in the consumer price.

With increasing awareness of the health benefits of sorghum in the last decade or so the demand for processed products made from sorghum is growing, though from a low base (particularly in India). Process and product upgradation of traditional value chain for sorghum will enable production and marketing of RTU products. Policies promoting public–private sector participation would enable greater private sector participation that would bring in product diversification and visibility and would further stimulate their demand.

References

Basavaraj G, Parthasarathy Rao P (2012) Regional analysis of household consumption of sorghum in major sorghum-producing and sorghum consuming states in India. Food Secur 4:209–217

Basavaraj G, Parthasarathy Rao P, Ravinder Reddy C, Ashok Kumar A, Srinivasa Rao P, Reddy BVS (2012) A review of national biofuel policy in India: a critique-need for promotion of alternative feedstocks. J Biofuels 3(2):65–78

Basavaraj G, Parthasarathy Rao P, More S, Pokharkar VG (2014) Analyzing pro-poor value chains—study of post rainy season sorghum in Maharashtra state of India. Presented at Global value chains for food and nutrition security 25–26, September 2014, Roma Tre University, Sala delle Lauree, School of Economics and Management, Via Silvio d'Amico 77, 00145, Rome

Bhagavatula S, Parthasarathy Rao P, Basavaraj G, Nagaraj N (2013) Sorghum and millet economies in Asia-facts, trends and outlook. International Crops Research Institute for the Semi-Arid Tropics, Patancheru. ISBN: 978-92-9066-557-1

Chavan UD, Yewale KV, Dayakar Rao B (2016) Preparation of bread and cookies from sorghum flour. Int J Recent Sci Res 7(5):11145–11153

Cuevas-Cubria C (2012) The impact of Australian ethanol policy on agriculture: examining limiting factors. Paper presented at 2012 AARES Conference, 7–10 February, Fremantle, Western Australia

Dayakar Rao B, Binu Mathew, Bharath Kumar KA, Karthikeyan K, Hymajyothi S, Shahid Parwez, Ratnavathi CV, Seetharama N (2003) Industrial utilization of sorghum in India-status and prospects. NRCS (National Research Center for Sorghum) Report Number 13, 16 pp

Dayakar Rao B, Bhargavi G, Kalpana K, Vishala AD, Ganapathy KN, Patil JV (2015) Development and standardization of sorghum pasta using extrusion technology. J Food Sci Technol 52 (10):6828–6833

Demeke M, Di Marcantonio F (2013) Analysis of incentives and disincentives for sorghum in Ethiopia. Technical notes series, MAFAP, FAO, Rome. http://www.fao.org/3/a-at474e.pdf

FAOSTAT (2018). http://www.fao.org/faostat/en/#data/QC

FAOSTAT (2020). http://www.fao.org/faostat/en/#data/QC

FSNWG (2014a) Food Security and Nutrition Working Group: East Africa cross border trade bulletin, January 2014. https://fews.net/sites/default/files/documents/reports/Quarterly%20GHA%20Cross % 20Border%20Trade%20Bulletin%20January%202014.pdf

FSNWG (2014b) Food Security and Nutrition Working Group: East Africa cross border trade bulletin, April 2014. http://www.fews.net/sites/default/files/documents/reports/Quarterly%20GHA%20 Cross%20Border%20Trade%20Bulletin%20April%202014.pdf

GOI (2016) Agricultural statistics at a glance, Directorate of Economics and Statistics. Government of India, New Delhi

Gourichon H (2013) Analysis of incentives and disincentives for sorghum in Nigeria. Technical notes series. MAFAP, FAO, Rome

Huacuja FE (2013) Agricultural policy and feed industry in Mexico. Mex Stud 29(1):61–84. https://doi.org/10.1525/msem.2013.29.1.61

ICRISAT (1996) The world sorghum and millet economies: facts, trends and outlook. FAO Rome ICRISAT, Patancheru. http://oar.icrisat.org/1024/

Kumara Charyulu D, Bantilan Cynthia, Rajalaxmi A, Reddy BVS, Borikar ST, Ashok Kumar A, Singh NP, Moses Shyam D (2014) Development and diffusion of sorghum improved cultivars in India: impact on growth and stability in yield. Working Paper Series no. 50. International Crops Research Institute for the Semi-Arid Tropics, Patancheru. 92 pp

Kumara Charyulu D, Moses Shyam D, Bantilan Cynthia, Borikar ST, Ashok Kumar A, Reddy BVS (2016) Rainy season sorghum technology adoption and impact study in Maharashtra. Research Report 70. ICRISAT, Patancheru. 80 pp. ISBN 978-92-9066-580-9

Marsland N, Parthasarathy Rao P (1999) Marketing of *Kharif* and *rabi* sorghum in Andhra Pradesh, Karnataka, and Maharashtra. Working Paper Series No. 1, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Patancheru, Hyderabad, 38 pp. https://agris.fao.org/agris-search/search.do?recordID=GB201210079

Mohamed A, Urge M, Gebeyew K (2015) Effects of replacing maize with sorghum on growth and feed efficiency of commercial broiler chicken. J Vet Sci Technol 6:224. https://doi.org/10.4172/2157-7579.1000224

Nagaraj N, Basavaraj G, Parthasarathy Rao P, Bantilan MCS (2012) Future outlook and options for target crops: the sorghum and pearl millet economy of India. Policy Brief no.15. RP Markets, Institutions and Policy (MIP), ICRISAT, Patancheru

Orr A, Mwema C, Gierend A, Nedumaran S (2016) Sorghum and millets in Eastern and Southern Africa. Facts, trends and outlook. Working Paper Series No. 62. ICRISAT Research Program, Markets, Institutions and Policies. International Crops Research Institute for the Semi-Arid Tropics, Patancheru. 76 pp

Parthasarathy Rao P, Birthal PS (2008) Livestock in mixed farming systems in South Asia. National Centre for Agricultural Economics and Policy Research, New Delhi, India; International Crops Research Institute for the Semi-Arid Tropics, Patancheru. 156 pp

Parthasarathy Rao P, Hall A (2003) Importance of crop residues in crop-livestock systems in India and farmer's perceptions of fodder quality in coarse cereals. Field Crop Res 84:189–198

Parthasarathy Rao P, Raghunadha Reddy G, Reddy BVS, Krishna Reddy K (2004) Economics of improved sorghum cultivars in farmers fields: Andhra Pradesh. Int Sorghum Mill Newslett 45:40–42

Parthasarathy Rao P, Birthal PS, Reddy BVS, Rai KN, Ramesh S (2006) Diagnostics of sorghum and pearl millet grains-based nutrition in India. SAT J 2(1). ICRISAT, Patancheru

Parthasarathy Rao P, Ravinder Reddy Ch, Alur AS, Reddy BVS, Gowda CLL (2009) Impacts of the CFC-FAO-ICRISAT livelihood improvement project in Asia: Region I—India. International Crops Research Institute for the Semi-Arid Tropics, Patancheru. 128 pp. http://oar.icrisat.org/1321/1/82_2009_Impact_of_CFC-FAO-ICRISAT_Reg-1_India.pdf

Rao KPC, Kumara Charyulu D (2007) Changes in agriculture and village economies. Research Bulletin no. 21. International Crops Research Institute for the Semi-Arid Tropics, Patancheru. ISBN 978-92-9066-507-6

Ravinder Reddy Ch, Jianqiu Z, Ashok kumar A, Parthasarathy Rao P, Reddy BVS, Gowda CLL (2012) Linking to markets: A case study of sorghum small scale farmers group in China. LEISA, INDIA pp 20–23

Srivastava A, Naresh Kumar S, Aggarwal PK (2010) Assessment on vulnerability of sorghum to climate change in India. Agric Ecosyst Environ 138:160–169

USDA (2017a) Grain: world markets and trade, September 2017, USDA, Foreign Agricultural Service, USA.

USDA (2017b) Grain report Australia 2017. Published by Global Agricultural Information Network, USDA Foreign Agricultural Service, USA

USDA (2017c) Grain report Argentina 2017. Published by Global Agricultural Information Network, USDA Foreign Agricultural Service, USA

USDA (2017d) Grain report China 2017. Published by Global Agricultural Information Network, USDA Foreign Agricultural Service, USA

USDA (2017e) Grain report Ethiopia 2017. Published by Global Agricultural Information Network, USDA Foreign Agricultural Service, USA

USDA (2017f) Grain report India 2017. Published by Global Agricultural Information Network, SDA Foreign Agricultural Service, USA

USDA (2017g) Grain report Mexico 2017. Published by Global Agricultural Information Network, USDA Foreign Agricultural Service, USA

USDA (2017h) Grain report Nigeria 2017. Published by Global Agricultural Information Network, USDA Foreign Agricultural Service, USA

Walsh B (2011) Why biofuels help push up world food prices. Time Magazine. 2011. http://www.time.com/time/health/article/0,8599,2048885,00.html

Wang H (2017) China's grain sorghum import demand: measuring the effect of policies on price relationships and future trends. Unpublished Doctoral Thesis, Mark Sheridan, Dean of the Graduate School, Texas Tech University, USA. https://ttu-ir.tdl.org/bitstream/handle /2346 / 73184/WANG-DISSERTATION-2017.pdf?sequence=1