Future Outlook and Options for Target Crops:
The Sorghum and Pearl millet Economy of India

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Background

More than 60% of the area in India is cultivated in arid and semi-arid conditions characterized by long dry seasons, inadequate and unpredictable rainfall and infertile and fragile soils, which provides around 40% of the food produced (Gulati and Kelley 2000). Farmers here are exposed to harsh agro climatic conditions, as they have to cultivate shallow and poor soils receiving low and erratic rainfall below 600 mm. Recurrent droughts coupled with frequent dry spells further exacerbate the situation. In the last few decades these regions are facing a shrinking natural resource base and land degradation, resulting in low productivity in crop and livestock sectors. This has contributed to increased poverty, malnutrition and indebtedness of smallholder farm families.

Limited crop choice in harsh environments

In the arid and semi-arid harsh environmental conditions, the cropping choice is restricted due to moisture stress, low soil fertility, poor and saline soils and lack of assured sources of irrigation. Dryland cereals like sorghum and pearl millet are hardy crops that thrive in such adverse agro-ecological situations making them less risky for production. Sorghum and millets continue to occupy a prime place in smallholder farming systems in arid and semi-arid regions providing employment, income and food for human consumption, and feed for livestock. At the same time, excessive dependence on rice and wheat for food self-sufficiency has not only made food security fragile, but has also shrunken the diversity of the food basket as they are resource intensive and inefficient in terms of crop output moisture response. In order to alleviate this problem and to make food more nutritional, healthy and affordable, coarse cereals (now recoined as nutritious cereals) like pearl millet and sorghum deserve to be promoted specifically in the wake of climate change.

In India, both sorghum and pearl millet are cultivated as dual purpose crops in over 9.3 and 8.3 m ha ranking third and fourth among total cereals, respectively (Yadav et al. 2011). Sorghum is widely cultivated during both the rainy and postrainy seasons in the regions of central and western parts of Maharashtra, and northern regions of Karnataka, Andhra Pradesh and Tamil Nadu, while pearl millet is produced in Rajasthan, Gujarat, Maharashtra, Uttar Pradesh and Haryana. Besides grain, millet and sorghum stover are an important feed for livestock especially in the dry months when other feed resources are in short supply. The sorghum grain produced during the postrainy season (rabi) is from local and improved landraces of superior quality (bold, white in color, with sweeter taste) and hence preferred for human consumption. By contrast, sorghum produced in the rainy season (kharif) is from hybrids with poor grain quality and less preferred for human consumption. About 50% of kharif produce is utilized for alternative uses such as poultry feed, alcohol and animal feed, while postrainy season sorghum is exclusively used as food (Parthasarathy Rao et al. 2010). Pearl millet, on the other hand, apart from being used as a staple food, is also used as poultry and animal feed, and for the production of alcohol and health foods.

Advantages of growing coarse cereals in the dry areas

In the rainfed regions of the country, where sorghum and millets are grown, they also form the staple diet of a majority of the poor smallholders and poor consumers. The advantages of growing these crops include: a) They use less external input, are drought tolerant, sturdy, short to medium duration, low labor utilizing crops resistant to pests and diseases, meeting food, nutrition and fodder requirements; b) Millets are C4 crops having carbon fixing properties (ie, climate change compliant). Further, in view of moisture stress, millets are the best alternatives for extreme weather conditions and are well suited to the drought prone regions; c) An important feature of sorghum and millets is its nutritional quality as food for the poor people. They are the richest sources of nutrition, especially iron, calcium and zinc among cereals and hence can provide all the nutrients at the

least cost compared to wheat and rice (Parthasarathy Rao et al. 2006); d) The crop residue of sorghum and pearl millet forms an important component of feed for livestock (Parthasarathy and Hall 2003). Despite these advantages, due to lack of economic incentives in the face of declining food consumption for these crops, both pearl millet and sorghum have been relegated as inferior crops in the country.

Focus

Considering the vital role of coarse cereals in the food basket and livestock economy, an economic analysis leading to policy steps towards promoting these crops is critical. This policy brief mainly focuses on the pearl millet and sorghum economy, analysing their growth and consumption trends, identifying the constraints in enhancing productivity growth and identifying potential areas for future investment, markets and policy options.

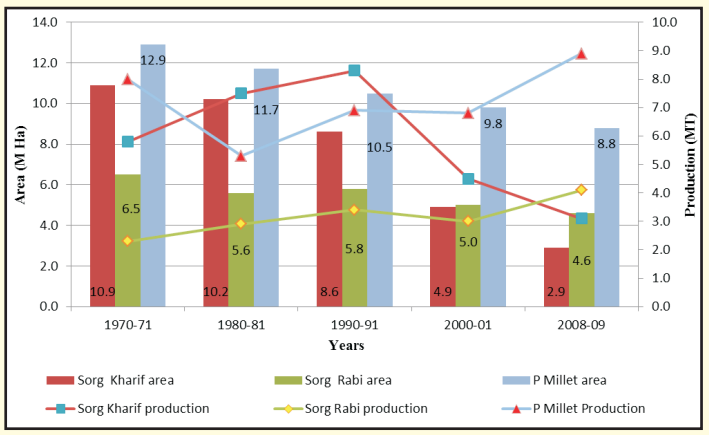
Area, Production and Productivity trends

The total sorghum area (kharif and rabi seasons) has shrunk over time from 17.4 million ha in 1970-71 to 7.5 million ha in 2008-09, registering a 56% decline over the past three decades, recording a negative growth rate of -1.23% per annum. The kharif area dipped at a faster rate (70%), than the rabi area (32%) between 1970 and 2009 (Figure 1). This is mainly due to diversion of kharif sorghum areas to crops like sunflower, maize, groundnut and pulses. Further, sorghum has been replaced by commercial crops such as sugarcane, cotton, onion and maize due to improved access to irrigation in some areas. Despite a sharp decline in the area, the production of kharif sorghum increased till 1990, due to the use of hybrids and improved cultivars, and gradually decreased thereafter owing to area decline without significant impact on production. After the 90s the yield increase also slowed down. The overall rabi sorghum production increased by 83% during 1971 to 2009, while the kharif sorghum production declined by 52%. Thus, currently, 55% of the area is under rabi sorghum compared to 35% in the 70s. In the case of pearl millet, area and production increased till the 1970s and declined during the 80s due to downy mildew epidemics (Pray and Nagarajan 2010). After the 1980s, though there was a marginal decline in area under pearl millet, accelerated productivity sustained production.

Waves of change in area, production and productivity trends during different periods

With the onset of the green revolution, the productivity of sorghum and pearl millet triggered appreciably. In most of the states in India, the trends of area, production and productivity of sorghum and pearl millet witnessed three waves of change. The 1st wave pertained to pre-green revolution period (1950 to 1960s), the 2nd wave was in the green revolution period (1970s to 1980s) and the third wave in the post-green revolution period (after 1990s). During the pre-green revolution period, traditional varieties were grown, hence the growth in output was driven by area expansion. During the green revolution period, there was appreciable increase in productivity due to high yielding varieties and hybrids, intensive use of chemical fertilizers and other improved package of practices.

Productivity registered an impressive growth rate of 40% during this period. However, for millet, owing to frequent outbreaks of downy mildew, the yield stagnated during the early 80s, and rebounded again in the mid 1980s with the release of varieties that were resistant to fungus with the assistance of ICRISAT (Pray and Nagarajan 2010). Thus, in the second wave of change, the growth in output was mainly productivity led due to technical change with access to markets. The third period is marked by release of varieties with value added attributes like resistance to pests and diseases, and drought and heat tolerance.



Source: Economic Survey, GOI 2010.

Figure 1. Area and production of sorghum and pearl millet in India, 1970-71 to 2008-2009.

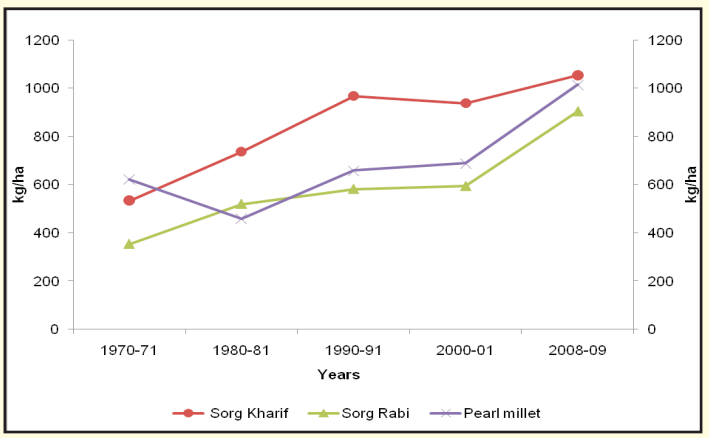


Figure 2. Productivity trend of sorghum (in kharif and rabi season) and pearl millet in India during 1970-71 to 2008-09 (kg/ha).

In this period too, area exhibited a declining trend but productivity increased in pearl millet at a higher rate compared to sorghum. Nevertheless, the production levels of both grains remained stable.

Though the productivity recorded a high compound growth rate of 2.5% per annum in kharif sorghum, there has been a wide productivity differential between kharif and rabi sorghum by 2-3 times. This is due to non-availability of improved cultivars for rabi sorghum and cultivation of rabi sorghum under residual soil moisture. The improved varieties occupy only 25-30% of the area under cultivation of rabi sorghum. The ex-ante analysis of improved technologies indicated that the additional cost of replacing the local variety with the improved variety is ₹ 3,413, yielding a net gain of ₹ 6,088 per ha with incremental returns to cost ratio of 1.78. The incremental income is ₹ 2,675. Similarly, the additional cost associated with replacing variety along with improved management practices is ₹ 4,083 with an incremental cost to return ratio of 3.51. With supplementary irrigation, the net gain increased to the tune of ₹ 14,418 per ha with incremental returns to cost ratio of 3.78. Thus, the contributing factors towards improved productivity in case of rabi sorghum are management practices such as nutrient management, critical irrigation and improved production technology.

Synergies from the public and private investment on sorghum R&D - Implications

The public sector, primarily national and state governments, monopolized investments in agricultural R&D, especially on food crops till the 1990s. The new technology led interventions were implemented by national and state governments working in collaboration with international institutes like International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). ICRISAT contributed genetic material to public and private institutions that helped to breed varieties resistant to biotic and abiotic factors. Using ICRISAT germplasm and breeding materials, 242 sorghum and 163 pearl millet varieties/hybrids have been released by NARS as of December 2010 (http://www.thehindubusinessline.com/industry-and-economy/agri-biz/article2047506.ece). These research institutes mainly focused on breeding varieties that are resistant to pests and diseases, while seed production was carried out by both the public and private sectors. After the 1990s, favorable government policies like liberalization in the private seed sector to produce truthfully labeled seed instead of mandatory registration and testing of new varieties by the Government and private sector encouraged seed multiplication and distribution. For instance, 82% of the seed supply of pearl millet and 75% of the sorghum is by private sector. (Pray and Nagarajan 2009). This has increased seed replacement rate phenomenally and productivity of sorghum and pearl millet has more than doubled, benefiting farmers. The increased productivity enabled farmers to allocate less area to millets and divert the saved land to other cash crops, improving the incomes of the farmers.

Comparative economics of sorghum and pearl millet production

The profitability of rabi sorghum is relatively higher as compared to kharif sorghum (Table 1). Farmers cultivating kharif sorghum realize a productivity advantage due to the adoption of hybrids like CSH 9, 16 and 23. The productivity of kharif sorghum is double that of rabi sorghum, where there are no hybrids. Thus, the cost of production per quintal is lower, while the farmers who produce rabi sorghum have a price advantage, as the price of rabi sorghum is higher than that of kharif sorghum. In case of pearl millet, the production cost per unit of output is low due to high productivity owing to large scale adoption of hybrids and the net margin realized per unit is also modest. Considering the current

Table 1. Comparative cost of cultivation of kharif sorghum, rabi sorghum (Maharashtra) and pearl millet (Rajasthan) in India.

Particulars	2009-10			2008-09			2007-08		
	KSG	RSG	PM	KSG	RSG	PM	KSG	RSG	PM
Total cost (Cost A*) (₹/ha)	14,820	11,391	7888	12,759	10,624	7099	14,124	8831	5680
Total return (₹/ha)	19,856	16,646	14,506	17,514	16,104	13,055	18,863	15,851	10,455
Net Return (over cost A)	5036	5255	6618	4755	5479	5956	4739	7021	4775
Returns to cost ratio (over cost A)	1.34	1.46	1.84	1.37	1.52	1.83	1.34	1.80	1.84
Productivity (qt/ha)	16.57	9.38	17.32	14.93	9.92	16.00	15.54	8.37	15.00
Cost of production per quintal	895	1214	456	855	1071	444	909	1055	379
Gross return per quintal	1199	1774	838	1173	1623	816	1214	1893	697
Net return per quintal	304	560	382	318	552	372	305	838	318

Source: Comprehensive Cost of Cultivation Scheme, GOI.
KSG – kharif sorghum, RSG – rabi sorghum, PM – pearl millet
** Cost A refers to all paid out costs, which approximates the expenditure incurred by the cultivator in cash and kind in the cultivation of crop.*

minimum support price of ₹ 880 per 100 kg of pearl millet, ₹ 900 for rabi sorghum and ₹ 880 per 100 kg of kharif sorghum, farmers are not able to get higher returns. Unless the price scenario changes, pearl millet and sorghum will not emerge as commercial crops and the area under these crops is likely to decline though the productivity may improve with the availability of improved technology. Area decline can be addressed through appropriate policies promoting these crops both at the farm level and at consumption level as nutritious cereals for consumers.

Economic importance of rabi sorghum

The bulk of the rabi sorghum output produced goes for human consumption, as the grain is of superior quality and highly preferred for consumption. As a result, rabi sorghum commands a premium price in the market compared to kharif sorghum by 20 to 40%. Similarly, rabi sorghum fodder is highly preferred as livestock feed, which is a key complementary activity in dryland agriculture contributing to total farm income. Economic contribution of fodder to the total income from rabi sorghum is to the order of 45 to 57% in varieties and 39 to 47% in hybrids in Maharashtra and Andhra Pradesh (DSR 2010).

Consumption trends

The annual per capita consumption of sorghum at the all-India level has declined sharply by 74% (8.5 to 2 kg) in urban areas and by 81% (19.2 to 3.5 kg) in rural areas of India between 1972–73 and 2009–10. Similarly, the pearl millet consumption both in rural and urban areas has fallen very steeply from 11.5 kg to 3.06 kg (by 73%) in rural areas and from 4 kg to 1.08 kg (by 73%) in urban areas (Fig 3 & 4) (Parthasarathy Rao et al. 2010 and Basavaraj et al. 2010). This is due to increase in per capita income, growing urbanization, changing tastes and preferences (Chand 2007) rendering sorghum and millet as inferior goods with low to negative income elasticity of demand and positive price elasticity. Apart from decline in consumption, these crops are gradually disappearing in traditional areas due to access to irrigation and markets, which have enabled farmers to shift their area under cultivation to high value crops (Chandrakanth and Akarsha 2011).

The food security strategy of the Government of India of supplying subsidized rice and wheat through the Public Distribution System (PDS) has been the major factor contributing to the decline in consumption of sorghum and other cereals like pearl millet and finger millet in rural areas and urban centers. Thus, the popularity of sorghum and pearl millet faded, resulting in negative growth in area, production and consumption as they could not compete with other remunerative crops due to market imperfections and market failure (to recognize nutritive properties), poor policy support and poor consumer awareness. Additionally, due to the improved access to irrigation, area under millets was gradually replaced by rice, maize and other high value crops. Due to low market price, farmers do not follow improved production practices and hence their cultivation became uneconomical.

The PDS system in India is based on the wheat and rice model, which is less relevant in many areas and especially in the dryland farming areas, where millets, sorghum and pulses are traditionally the staple grains for household consumption (Dayakar Rao, Reddy and Seetharama 2007). Hence, despite the decline in per capita consumption, sorghum grain is an important staple for the low and middle income consumers in regions where they are grown. For example, in rural areas of central Maharashtra, per capita annual consumption of sorghum is around 60 kg, accounting for almost half (48%) of the per capita consumption of all cereals. Similarly, among the major pearl millet producing regions, per capita consumption was highest (69 kg/year) in rural Rajasthan and in the dry areas of Gujarat (59 kg/year). In these two regions, pearl millet accounts for more than 50% of cereal consumption, contributing about 20 to 40% of the total energy and protein intake (Parthasarathy Rao et al. 2009).

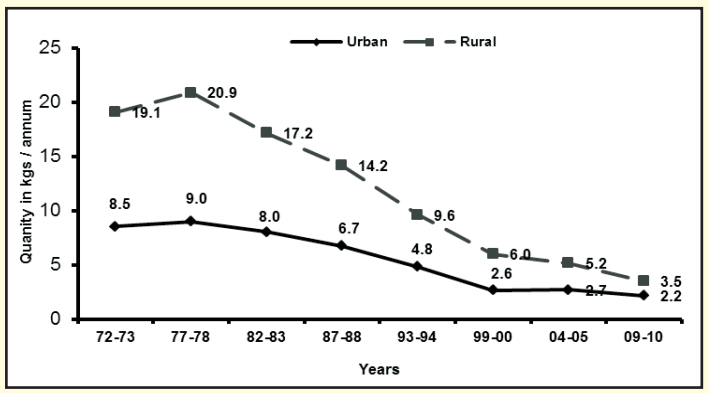


Figure 3. Trends in the annual per capita consumption (PCC) of sorghum in rural and urban India, 1972 to 2010.

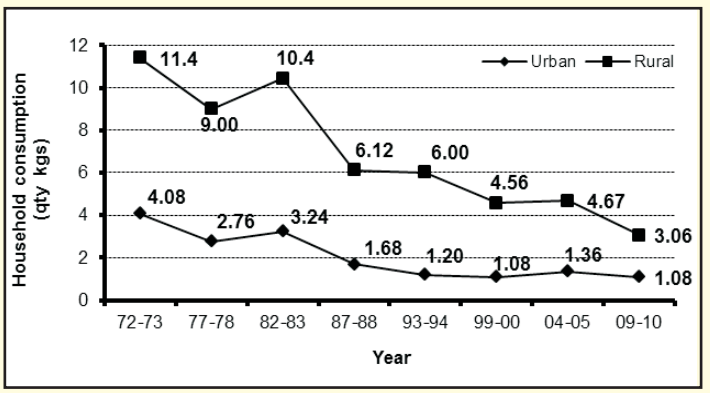


Figure 4. Trends in annual per capita consumption (PCC) of pearl millet in rural and urban India, 1972 to 2010.

Markets

Traditionally, sorghum and pearl millet are being grown for home consumption and not for marketing. Hence, the market participation was quite low and so also their price response. As a result, these crops never fetched the prices equivalent to the superior cereals. Currently, with increasing importance of alternative uses, the producers sell a portion of their produce as marketable surplus and are more concerned about the prices received for the crop that they sell. Minimum Support Price (MSP) mechanism has not been effective in this respect as the marketing of the produce is not in bulk and it is mostly sold in the local market. These crops have received unfair treatment on the price front (Deshpande and Rao 2003). Market for millets (except maize) is undergoing a change from near perfect markets to imperfect markets. This is due to lack of consumer demand for millets including demand from farmers themselves who produce these crops. As these farmers face relatively imperfect markets compared with that of superior cereals, pulses and oilseeds, the low prices received will lead them to be economically inefficient, just covering or even not covering the production costs. Market efficiency can be improved by the addition of a processing facility to handle excess produce in times of maximal production and by allowing for an expansion beyond the market for grains. The producers, by organizing as a group, will be able to obtain market power, thereby increasing their share of the increased profits in the chain.

Constraints

The millet based production system in arid and semi-arid regions greatly suffer from biotic and abiotic stresses like frequent droughts and uncertain rainfall; soil nutrient deficiencies especially phosphorus, nitrogen, and organic matter; major pests such as shootfly, stem borer and earhead bug and major diseases like grain mold and charcoal rot.

Availability of quality inputs like seeds, fertilizers and other inputs at the right time and place is a major constraint farmers are facing in dry areas. Labor scarcity, particularly during harvesting, is yet another critical constraint reducing the profit margin of rabi sorghum. Farmers in the drylands tend to under-invest in fertilizers due to price risk and uncertainty. Lack of credit and input supply bottlenecks are common factors precluding optimal production. Lack of improved storage facilities at farm level is another constraint. Postharvest processing of millets is in its infancy with no policy support, relegating millets. The most common complaint of small holder farmers in rural India is the lack of access to stable markets and market led extension. Unorganized markets, asymmetric information, superfluous middlemen, little vertical coordination between producers, processors and consumers, meager bargaining power, poor transportation links and lack of processing opportunities are making millets less remunerative.

Potential area for future investment

In marginal and harsh environments, the options to shift from millets to other lucrative crops is limited. Hence, farmers demand productivity augmenting technologies that are cost effective and land saving. Productivity of kharif sorghum is twice that of rabi sorghum, since enhanced productivity gain is not substantial in rabi sorghum due to lack of varieties/hybrids that have grain quality on par with the local varieties, Maldandi and M35-1, which have better consumer preference for grain and fodder. In addition, the new sources of demand for sorghum and pearl millet are also emerging for other uses. Hence, investments should flow towards breeding varieties incorporating the quality attributes preferred by end users. It goes without saying that breeding efforts for value added characteristics like tolerance to drought, downy mildew, smut, blast, heat and bird loss, should continue as the yield loss due to these factors is to the tune of 30-50%. The second priority is to breed varieties to increase the shelf life of grain and reduce the undesirable attributes in the grain like reducing fat content and phenol compounds, followed by improving the keeping quality of the flour and exploring health benefits and nutriceutical value for pearl millet.

Industrial demand for grain-based alcohol is also expected to propel a double digit growth rate. There is a good demand for pearl millet towards extraction of alcohol, provided the starch content in pearl millet is increased from the present level of 55% to 65%. Presently, most distilleries are using broken rice, as rice has high starch content and the unit cost of starch from rice is cheaper than starch from pearl millet. Hence, the demand for pearl millet from the distilleries depends on the relative prices of broken rice and pearl millet. Thus private-public partnership and investment is required to breed varieties with high starch content, targeting 100% substitution of maize, rice, etc, with pearl millet.

Investment in research should be directed towards increasing productivity of rabi sorghum, which would help in bringing down the prices and make it affordable for lower income consumers. In order to improve productivity of rabi sorghum, besides targeting improved varieties, targeting the key recommended technologies, management practices like microdosing, seed treatment, deep sowing, wide row spacing, optimum plant population, Integrated Pest Management (IPM) and Integrated Nutrient Management (INM) is crucial. In addition, moisture use efficiency towards reducing drought risk is also important.

Exploring non-conventional uses and extrusion products is another important area for future investment in these crops. Incentives should be provided to the food industry to use rabi sorghum for novel processed food products (snacks, bread, biscuits, flakes, papad, rava, etc) and also traditional processed products. Value addition in millets is now crucial to widen markets, for consumer acceptance and to render cultivation of these crops remunerative for producers. Though potential exists for bakery products, nutrifoods, nutraceuticals and health foods, value addition in millets is in infancy stage with no research and policy support. Enriching nutritional value in pearl millet, like zinc and iron content, is yet another fertile area for investment. Thus, there is wide scope to invest in nutrition technologies, which will have a ripple effect on the improvement in the livelihoods of dryland farmers in marginal areas who are dependent on cultivation and consumption of crops like sorghum and pearl millet.

Research and Policy imperatives

The research efforts mainly targeted at improving rabi sorghum has not been accorded much importance. Even now, for rabi sorghum, the bulk of the area is occupied by Maldandi, a local land race and M-35-1. The average replacement of seed during the cultivation of postrainy sorghum is 16 years. Further, biological and environmental factors constrain yield improvement in the rabi season. Thus, the research priority in the case of rabi sorghum should address enhancing productivity of grain and fodder yield under residual moisture situation. Any significant increase in productivity requires the use of crop improvement and management technologies and market support for economic incentive. In addition, the biotic and abiotic stresses such as resistance to shootfly, aphid, charcoal rot, drought and cold are important for adaptation in the rabi season. Consumer acceptability is towards bold, round and lustrous grain and higher flour recovery. Thus, research efforts on rabi sorghum should address the above problems on priority in order to augment productivity and thus render sorghum as a profitable crop benefiting the small and marginal farmers in SAT areas.

Chronic under nourishment, especially deficiency of micronutrients, the "hidden hunger" is rampant in India. Hence, millets need to be included in the diets to address micronutrient deficiency. But urban dwellers view it as a "poor man's crop" and it has thus become an inferior good. The Government must include millets in the PDS as a quid pro quo measure in the National Food Security Mission. Millets need also to be integrated with Integrated Child Development Services (ICDS), Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) and School Mid-day Meals programs wherever these crops are predominantly grown.

Policy bias towards procurement and support prices for dryland cereals

Even though minimum support prices (MSP) are offered for millets similar to rice and wheat, farmers are not responding to millet cultivation due to (1) absence of procurement operations (2) lack of consumer demand as millets are treated inferior goods (3) poor value addition (4) poor consumer awareness and (5) lopsided policy support compared to rice, wheat and other commercial crops.

Though MSP has been announced for dryland cereals, they are procured very rarely. Thus the MSP has become notional. Further, the differences between the prices of coarse cereals, on the one hand and wheat and paddy on the other, is widening. Thus, there is a raw deal in price support for the coarse cereals. Unless the price scenario changes, pearl millet and sorghum will not emerge as commercial crops and the area under these crops is likely to decelerate though the productivity may improve with the availability of improved technology.

Public Distribution System (PDS) has been the major factor contributing to the decline in consumption of dryland cereals

Rice and wheat have been distributed through the PDS at subsidized prices for the people who are below the poverty line. This has severely affected the consumption pattern of cereals, as the price of dryland cereals is much higher compared to the subsidized prices of rice and wheat. Thus, change in consumption pattern affected the growth of coarse cereals.

The price disadvantage of rainfed farmers due to lack of storage and bargaining capacity is exploited by middlemen who garner the produce during peak arrivals at harvest time and then store the grain to reap the time utility. The vertical integration capacities of small and marginal farmers are virtually non-existent or poor, which puts them at an additional disadvantage.

Since sorghum and pearl millet are occupying a prime place in the food basket in Maharashtra, Karnataka, Andhra Pradesh, Rajasthan, Gujarat and Haryana, efforts should be made at policy making level to include sorghum and millet in the PDS in these states. This will, in the long run, help both the producers and consumers. It will provide incentives to producers to grow sorghum and to consumers, if it is made available at cheaper price, for consumption as in the case of rice and wheat.

Policy makers should facilitate forward linkages where farmers enter directly into agreements 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.

In order to make a case for millets and raise the demand from the consumers, establishing a link between health and consumption of traditional food-grains is crucial and this needs initiatives from different stakeholders.

ICRISAT HOPE Project

Of late, cost of agricultural production has been increasing, resulting in low returns to farmers. Hence, farmers require efficient cost effective input delivery along with technological innovations to increase productivity and profitability through effective value addition and market linkage. In this regard, the project entitled Harnessing Opportunities for Productivity Enhancement (HOPE) of Sorghum and Millets in South Asia funded by the Bill & Melinda Gates Foundation, operating at ICRISAT aims at improving productivity of sorghum and millets in targeted areas of India by 35 to 40% during the first four years of the project through Inclusive Market Oriented Development.

Conclusions

Pearl millet and sorghum are predominately grown in arid and semi-arid regions of India under rainfed conditions and continue to play a prominent role in the dryland economy in view of limited scope for expansion of irrigated area. Further, these crops possess unique features such as high nutritive value and higher fodder value, and are drought tolerant. The productivity of these crops increased significantly during the green revolution era due to public and private investments in R&D. Though there was productivity enhancement, due to lack of economic incentives and effective demand, farmers reduced the area under millets by shifting to other crops to eke out their livelihood. While sorghum and pearl millet can substantially contribute to food, nutritional and economic security of small and marginal farmers, to stimulate demand for pearl millet and sorghum, value addition at micro and macro levels with technological support and market led extension through food science and nutrition is crucial. The very fact that rabi sorghum has not made inroads despite R&D contributions enhancing productivity, in itself is a prima facie indicator that productivity addresses only the supply side, while consumer demand is crucial, which is possible through value addition and extension efforts incorporating the nutrition and health aspects and meeting the quality requirements of alternative users that are emerging. Farmers have been resistant to switch over to improved varieties in case of rabi sorghum because of fodder quality. Thus, high yielding varieties with fodder quality on par with local races are required to improve the profitability of rabi sorghum.

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Appendix-I

Hotspots of sorghum and pearl millet area, production and consumption in SAT India.					
Crop	State	Area share to all-India area	Production share to all India production	Share of consumption	Important districts within the state
Sorghum	Maharashtra	53.43	50.49	66	Solapur, Jalna, Aurangabad, Beed, Latur, Parbhani, Osmanabad, Ahmednagar, Pune, Kholapur, Akola, Washim
	Karnataka	17.80	22.94	83	Belgaum, Bagalkot, Bijapur, Gulbarga, Bidar, Raichur, Koppal, Gadag, Dharwad, Haveri, Bellary, Chitradurga, Davanagere
	Andhra Pradesh	4.26	5.93	65	Kurnool, Anantapur, Cuddapah, Chittoor
Pearl Millet	Rajasthan	53.05	42.36	40	Ganganagar, Hanumangarh, Bikaner, Churu, Nagaur, Jodhpur, Jaisalmer, Barmer, Jalor, Sirohi, Pali
	Gujarat	9.62	13.11	100	Kutch, Banaskantha, Patan, Santalpur, Radhanpur, Harij, Sami, Chanasma, Surendranagar, Patan, Vagdod, Siddhpur, Rajkot, Jamnagar, Porbandar, Junagadh, Amreli, Bhavnaga,Mahesana, Sabarkantha, Vadali, Idar, Himatnagar, Prantij, Talod, Modasa, Dhansura, Malpur, Bayad, Gandhinagar, Ahmedabad, Anand, Kheda
	Maharashtra	13.41	11.30	NA	Ahmednagar, Nasik, Dhule, Beed
	Haryana	6.58	11.64	10	Jind, Fatehabad, Sirsa, Hisar, Bhiwani, Mahendragarh, Rewari

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