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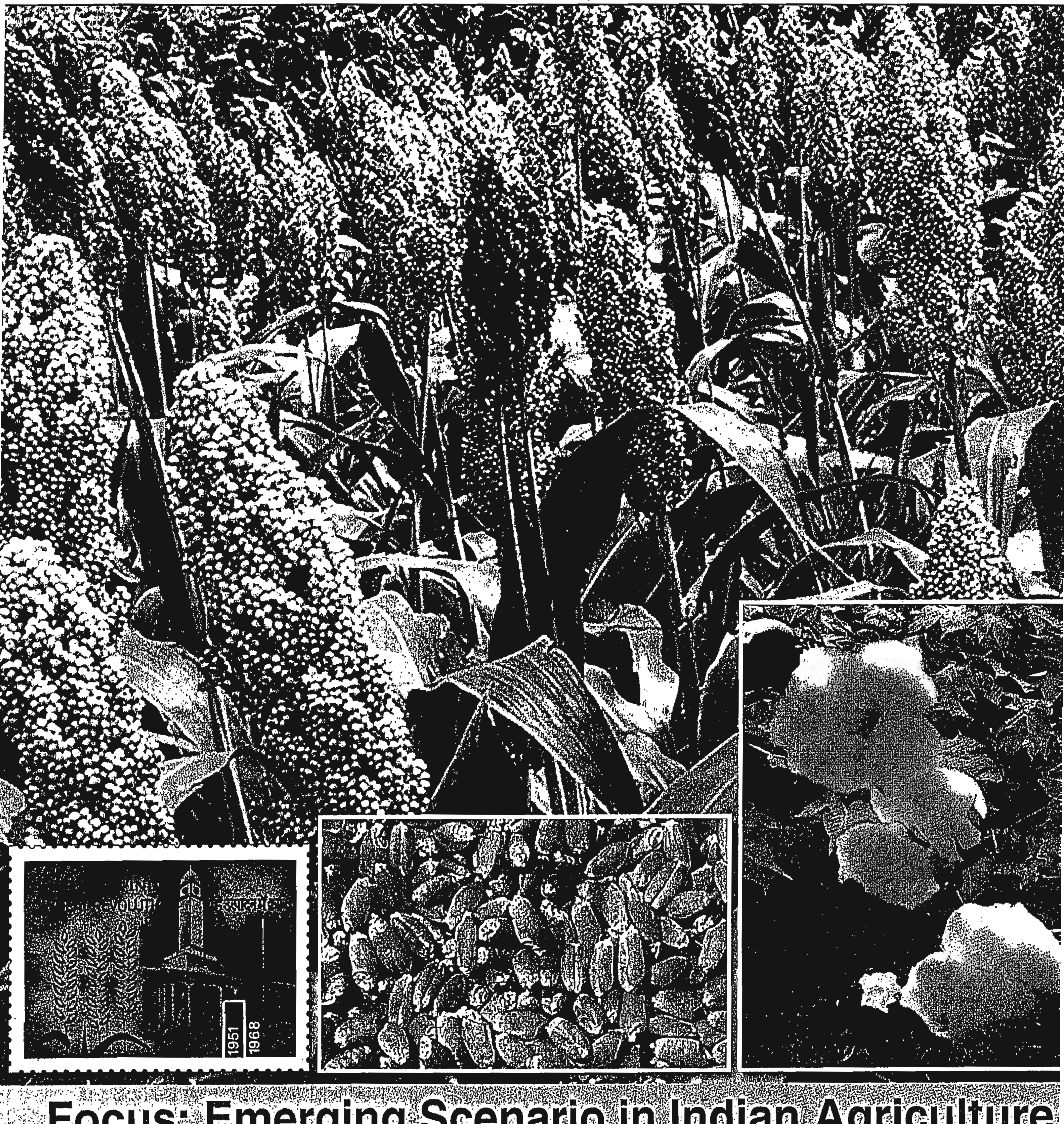

Focus: Emerging Scenario in Indian Agriculture

From Subsistence to Market-Oriented Agriculture: Sorghum Case Study

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Utilisation of sorghum for alternate product development would not only help in diversified utilisation but also translate into increased demand, thereby increased income to the farmers.

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INTRODUCTION

Sorghum (*Sorghum bicolor*) is a major cereal ranking fifth in the world after rice, wheat, maize and barley. It is the third important staple foodgrain after rice and wheat for millions of the poorest and most food-insecure people in the Semi-Arid Tropics (SAT) in India. Being a C_4 species with higher photosynthetic ability, and greater nitrogen and water-use efficiency, sorghum is genetically well suited to the hot and dry agro-ecosystems where it is difficult to profitably cultivate other foodgrain crops such as maize.

Cultivation and Traditional Utilisation

Grain and/or dual-purpose (both grain and dry fodder) sorghums are cultivated in Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Madhya Pradesh, Gujarat, and parts of Rajasthan. However, fodder/forage sorghums are cultivated in Haryana, Uttar Pradesh and parts of Rajasthan. Unlike in other parts of the world, sorghum is grown both in rainy (Kharif) and post-rainy (Rabi) seasons in India.

While the rainy season sorghum grain is used both for human consumption and livestock feed, postrainy season produce is primarily used for human consumption. Sorghum is traditionally consumed in the form of unleavened bread *(bhakri/roti), sankati*, and *Ganji* (thin porridge). In SAT India, sorghum is truly a dual-purpose crop (grain and stover). In large parts of SAT India, sorghum stover represents up to 50 per cent of the total value of the crop, especially in drought years (FAO and ICRISAT, 1996). Sorghum also offers great potential to supplement fodder requirement of the growing dairy industry in India because of its wide adaptation, rapid growth, high green fodder yield, and good fodder quality (Pahuja *et al.* 2002).

Production and Consumption Patterns

Production and consumption patterns of sorghum have changed significantly in India in the last two decades and this has important implications for sorghum improvement research programmes. Sorghum is becoming less important in the economies of the SAT India, and the demand for the grain (especially rainy season-produced grains) for food purposes has been declining in the past 30 years (Ryan and Spencer 2001). The grain quality deterioration in rainy season sorghum due to frequent infection by grain mold fungi, improving life standards, changing consumers' preference and taste, and supply of preferred finer grains such as rice and wheat through Public Distribution System (PDS) at prices lower than that of open-market price of sorghum have been attributed as the major reasons for the declining use of sorghum for food. Coupled with productivity improvement driven by adoption of high-yielding cultivars and improved crop production and protection practices, surplus production has led to price reduction. Obviously, this has negative economic impact on the resource-poor rainfed SAT farmers, who have fewer crop options, as they cannot get remunerative price for the produce and thereby are forced into the vicious cycle of poverty and indebtedness.

The decline in the demand for grains produced in the rainy season for food use coupled with low profitability of sorghum vis-à-vis competing crops, minimum support price offered by the government to production, seed propagation and comparable ethanol production capacity of sweet sorghum (5600 litres ha^{-1} yr^{1} over two crops; 70 t ha^{-1} of millable stalk $crop^{-1}$ @40 litres t^{-1}) vis a vis sugarcane molasses (850 litres ha^{-1} yr^{1}; 3.4 t ha^{-1} @ 250 litres t^{-1}) and sugarcane (6500 litre ha^{-1} $crop^{-1}$; 85-90 t ha^{-1} of millable cane $crop^{-1}$ @ 75 litres t^{-1}) (as per the pilot study by Vasantadada Sugar Institute [VSI], Pune) make sweet sorghum the best alternative source of raw material that can be used as a supplementary raw material for ethanol production.

Comparative Economics of Sweet Sorghum-based Ethanol Production

A techno-economic feasibility study undertaken by National Research Center for Sorghum (NRCS), Hyderabad, Andhra Pradesh, with active collaboration with M/s Renuka Sugars Ltd, Belgaun, Karnataka indicated that the per litre cost of production of ethanol from sweet sorghum (about Rs.13.11; @Rs.500 t^{-1} stalk) is slightly lower than that from sugarcane molasses (about Rs.14.98; @Rs.2000 t^{-1}). Besides stalks for ethanol production, sweet sorghum varieties produce grain yield of 2 to 2.5 t ha^{-1} (which can be used as food/feed or for potable alcohol preparation). Further, the stillage from sweet sorghum after the extraction of juice has a higher biological value than the bagasse from sugarcane when used as forage for animals, as it is rich in micronutrients and other minerals (Seetharama *et al.* 2002). It could also be processed as a feed for ruminant animals (Sumantri and Edi Purnomo 1997). The stillage contains similar levels of cellulose as sugarcane bagasse. Therefore, it has a good prospect as a raw material for pulp products. Blending sweet sorghum juice up to 10 per cent in sugarcane juice does not affect crystallisation; hence it is compatible with sugarcane industry (as per pilot study by M/s. Renuka Sugars Ltd.). Apart from these, the pollution level in sweet sorghum-based ethanol production has one fourth of biological oxygen dissolved (BOD) i.e. 19,500 mg/litre and lower chemical oxygen dissolved (COD) i.e., 38,640 mg/litre, compared to molasses-based ethanol production (as per VSI pilot study). Further, ethanol is a "clean burning fuel" with high octane rating. Thus, the existing automobile engines can be operated with Gasohol (petrol blended with ethanol) without any need for engine modification. From both economics and environment protection points of view, sweet sorghum offers good prospects for ethanol production.

NRCS and ICRISAT are the premier research institutes engaged in sweet sorghum improvement research. Excellent sweet sorghum varieties and hybrids have been developed for use in ethanol production by the sugar industries/alcohol distilleries. Considering early maturity, higher biomass potential and photoperiod insensitiveness of hybrids compared to varieties, it is desirable to promote the cultivation and use of hybrid sweet sorghums for ethanol production. The requirement of photoperiod insensitiveness is essential to facilitate plantings at different dates to ensure round-the-year supply of sweet sorghum stalks to distilleries for ethanol production. Therefore, sweet sorghum hybrid parents' research is being given strategic importance at ICRISAT for enhancing genetic potential of sweet sorghum.

Potable Alcohol

Commercially viable and potable alcohol made from rainy season moldy sorghum grain can be used both as liquor and in the pharmaceutical industry. This alcohol is much cleaner because of low sulfates and aldehydes. While the former gives sulfurous odour and bad taste, the latter has deleterious effects on health, if consumed in large quantities. Grain alcohol is used for potable purposes in developed countries. However, in India, molasses-based alcohol is being used for manufacture of alcoholic beverages, despite the fact that it contains high aldehydes and sulfates (Sheorain *et al.* 2000). Among the cereals, sorghum can be a better competitive raw material for alcohol production because of its low price. It offers a lucrative 63 per cent return (Ratnavathi *et al.* 2004). With modern technology, the inclusion of sorghum in alcohol production does not have any major technical constraint. Farmers are offered low price for kharif grain, particularly when the grains are moldy. Alcohol made from grain sorghum could be a good alternative to produce blended petrol (gasohol), in addition to use in liquor industry. Alcohol yield from clean sorghum or moldy sorghum (422-448 L t^{-1} grain and 390-435 L t^{-1} grain, respectively) is higher than that from maize (370-410 L t^{-1} grain) (Mandke and Kapoor 2004). Therefore, considering the lower price of sorghum (especially moldy sorghum) vis-à-vis maize, and alcohol yield, sorghum has comparative advantage for potable alcohol production. The cultivars with high starch and moderate protein in the grains are most desired by industry. A study conducted by NRCS with Seagram R&D Institute located near Nashik, Maharashtra revealed that CSH 16 and CSH 18 are the superior hybrids (Seetharama *et al.* 2002) for alcohol starch from maize can also be used for sorghum, with slight modifications. Starch recovery from sorghum grain is 5-8 per cent less than that from maize, but is equally lustrous. Recovery could be increased by increased grain size, and reduced protein and fibre contents. Sorghum, being a cheaper source for the production of starch and starch by-products, can substantially occupy a pivotal position. Liquid glucose and high fructose syrup (HFS) can be prepared from starch. Maltodextrins prepared from sorghum starch are used in the preparation of low calorie-low fat cookies in the baking industry (Anonymous 2002).

Sorghum grains are a rich source of dietary fibre, phytochemicals, and micronutrient, etc. However, sorghum grain consumption is restricted to lower income groups of population. Constraints in utilisation of sorghum grains include the presence of antinutritional factors and development of odor after milling due to high fat content and increased enzymatic activity. To overcome these constraints, sorghum grain could be subjected to various processing treatments including blanching, malting, dry heating, acid treatment, popping etc. (Sehgal *et al.* 2004). Sorghum can be utilised for development of a variety of food products. These include traditional products (porridges, flat breads, chips, *Bhakli, Suhali, Khichri, Dalia, Shakkerpara*), baked products, extruded products, health products, weaning and supplementary foods, etc. It has also been found that the products developed from processed flour have increased shelf life and higher starch and protein digestibility than products prepared from unprocessed flour (Sehgal *et al.* 2004). Utilisation of sorghum for alternate product development would not only help in diversified utilisation but also translate into increased demand, thereby increased income to the farmers. However, there is need to popularise the new products developed from sorghum among the processors and consumers.

Policy Changes

For enhanced role of sorghum in the food security and improved livelihoods of the farmers, innovations, both technical and institutional, need to be promoted urgently through a broader and more iterative set of relationships than those embodied in conventional research-extension-farmer model of agricultural development. Lack of access to markets is a greater constraint to the diversified livelihoods of resource-poor rural households, than the lack of access to food per se. Utilisation of sorghum grains for poultry feed, value-added food products, potable alcohol manufacturing etc. has created market opportunities and there is potential for expansion both in terms of scope and volume. However, the institutional arrangements (rules and norms) and relationships (partnerships and alliances) linking research and development organisations with sorghum producers, sorghum-based markets, and food and feed manufacturers need to operate more effectively than they do now. Marketing, contract farming and farmer-industry linkages are the niches for commercialisation of sorghum. Following are some of the suggested policy issues that need to be addressed to promote alternative uses of sorghum to make it a competitive crop rather than a mere subsistence food staple crop.

1. Create awareness about sweet sorghum among farmers by arranging field demonstrations on recommended production practices to take up sweet sorghum cultivation, in place of rice and sugarcane which require more water.
2. Encourage sweet sorghum cultivation by arranging subsidies and incentives and buy-back facility of sweet sorghum stalks by distilleries.
3. The existing sugar industries should include ethanol production facility, and new distilleries should be given capital subsidy or tax concessions on machinery, raw material, power and water supply, etc.
4. Buy-back facilities should also be arranged between major oil

TABLE 1: Comparative Nutritional Values of Sorghum and Maize Grains

Crop	Dry Matter (%)	Protein (%)		Total Digestible Nutrients (%)	Energy (k cal kg^{-1})		Ca (%)	P (%)
		Total	Digestible		Digestible	Metabolizable		
Sorghum	87	15.2	7.3	86	3772	3093	0.12	0.44
Maize	89	8.9	6.8	81	3571	2928	0.02	0.31

Source: Somani and Taylor (2004)

Ryan, J.G., and Spencer, D.C. 2001. *Future Challenges and Opportunities for Agricultural R&D In the Semi-arid tropics.* Patancheru, India: International Crops Research Institute for the Semi-arid tropics. Pp.83.

Seetharama N, Dayakar Rao B, Ratnavathi CV, Shahid Parwez Md, Binu Mathew, and Bharath Kumar KA. 2002. Sorghum as a Raw Material for Alcohol Production. Presented at the Seminar on Current Development in Alcohol Industry Organised by Distillers' Association of Maharashtra, 25 August 2002, Sahar, Mumbai, India.

Sehgal S, Kawatra A and Singh G. 2004. Recent Technologies in Pearl Millet and Sorghum Processing and Food Product Development. Pages 60-92 in *Alternative Uses of Sorghum and Pearl Millet in Asia*: Proceedings of the Expert Meeting, ICRISAT, Patancheru, Andhra Pradesh, India, 1-4 July 2003. CFC Technical Paper No. 34.

Sheorain. V, Banka, R and Chavan, M. 2000. Ethanol Production from Sorghum. Pages.228-239 In *Technical and Institutional Options for Sorghum Grain Mold Management* (Arun Chandrashekar, Ranjit Bandyopadhyay and Andrew Hall eds.). International Crops Research Institute for the Semi-arid Tropics, Patancheru, Andhra Pradesh, India. 295Pp.

Somani RB and Taylor JRN. 2004. Sorghum: A Potential Source of Raw Material for Agro-Industries. Pages 146-168 in *Alternative Uses of Sorghum and Pearl Millet in Asia*: Proceedings of the Expert Meeting, ICRISAT, Patancheru, Andhra Pradesh, India, 1-4 July 2003. CFC Technical Paper No. 34.

Soltani A and Almodares A. 1994. *Evaluation of the Investments In Sugar Beet and Sweet Sorghum Production.* National Convention of Sugar Production from Agriculture Products, 13-16 March 1994, Shahid Chamran University, Ahwaz, Iran.

Sudershan RV, Vasanthi S and Bhat RV. 2004. Utilisation of Fermented Moldy Sorghum as Cattle Feed. Pages 322-325 in *Alternative Uses of Sorghum and Pearl Millet In Asia*: Proceedings of the Expert Meeting, ICRISAT, Patancheru, Andhra Pradesh, India, 1-4 July 2003. CFC Technical Paper No. 34.

Sumantri A and Edi Purnomo. 1997. Sweet Sorghum Research and Development In Indonesia. Pages 49—54 in *Proceedings of the First International Sweet Sorghum Conference,* 14—19 Sep 1997, Beijing, China (Li Dajue ed.). Institute of Botany, Chinese Academy of Sciences, Beijing, China.

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Genetic Engineering

Traditional farming has always been based on genetic engineering. Every major crop plant and farm animal has been genetically engineered by selective breeding until it barely resembles the wild species from which it originated. Genetic engineering as the basis of the world economy is nothing new. What is new is the speed of development. Traditional genetic engineering took centuries or millennia to produce the improved plants and animals that fed the world until a hundred years ago. Modern genetic engineering, based on detailed understanding of the genome, will be able to make radical improvements within a few years. That is why I look to the genome, together with the sun and the internet, as tools with which to build a brighter future for mankind.

– Freeman Dyson
The Sun, the Genome,
& the Internet