Biodiversity of Sugarcane (*Saccharum* Species) for Development and Poverty Alleviation

D. K. Pandey*, Sanjeev Kumar, P. K. Singh, J. Singh, M. Swapna & R. K. Singh

Indian Institute of Sugarcane Research, Rae Bareli Road , Lucknow -226 002
*Email : dineshkamalapandey@yahoo.co.in

Agricultural biodiversity is a term that includes all components of biodiversity at genus, species and ecosystem levels that are relevant to food and agriculture and that support the ecosystems in which farming occurs. This includes the crop and live stock species, the varieties and breeds within these species and also those components that support agricultural production system. Components at species level that support ecosystem services include earthworms, bacteria and fungi that contribute to availability and cycling of plant nutrients through the break down and decomposition of organic material.

Biodiversity in our country has been the driving force for creating new areas of opportunities for employment of Indian people of rural background as well as for the industries. Different agricultural crop biodiversity have been exploited by judicious use of variety of non forest produce, herbs, medicinal plants, animal products, sugarcane products and by-products (table 1). Sugarcane species in particular have been used as raw material for other industrial products like ethanol, vinegar, pharmaceutical drugs, fertilizer, glucose etc. as well as renewal of energy as non conventional source

Sugarcane is an important crop in the country economically, politically and sociologically. It is the second largest agro-industry next to textiles. Sugarcane is grown in an area of 4.396m ha, producing 274m tonnes of cane yield with productivity of 62.3 tonnes per hectare. Out of this about 60% goes to the white sugar industry and the remaining is utilized for "Gur", khansari, seed, juice etc. The country produces more than 14.5 m tones of sugar with recovery of 10.03% through more than 488 sugar mills and nearly 35 million persons are engaged in the production of cane and sugar.

Centre of diversity and its distribution of sugarcane

The geographical origin of *S. officinarum*, sometimes called as noble canes is considered to be in the Malasia -Indonesia- Papua- New Guinea region or in the islands of Polynesia or Melanesia groups. *S. officinarum* is thick stalked noble cane rich in sucrose. The subject of their botanical origin has been of much speculation.

S. barberi, the indigenous subtropical form of North India, was used for sugar production for centuries and were considered to be evolved and grown since earliest recorded times. These were distributed though Punjab, UP, Bihar, Bengal and Assam. The different forms of these canes were classified by Barber in 1916 based on vegetative characters into five groups-Mungo, Nargari, Saretha, Sunnabile, Pansahi .

In distribution, Saretha (Chunee, saretha, kansar) was found in Punjab and between Assam and Bihar, Mungo and Nargari were distributed in waterlogged areas of Bihar. Sunnabile group was dominant in Assam while Pansahi group(Uba, Tekcha) was distributed between Bihar and Bengal. *Miscanthus* is suggested to have been evolved in China -Japan region from natural hybridization of *S . officinarum* and *S. sinense*. Genus *Saccharum*, *Saccharum* complex and S. barberi might have their origin in India- Burma-

China border region. It is in the Saretha group (Chunee and Kansar) that the most useful breeding canes of *S. barberi* have been extensively used to develop breeding lines/varieties for subtropics. The traditional knowledge of people about different basic species of sugarcane like *Saccharum officinarum, S. spontaneum, S . robustum, S. edule, Erianthus , Miscanthus, Sclerostachya* needs to be well recognized, documented and researched.

S. barberi (including churnee and khansar) are found in a number of tri-specific hybrids of subtropical India . The Saretha group is the only group with clones that flower and could be involved in the active evolution of the species. *S. barberi* arose from introgression of *S. officinarum* with *S. spontaneum* in India. *S. sinense* is the product of *S. officinarum* and *Miscanthus sacchariflorus* introgression in China.

Conservation of sugarcane diversity

Conservation of plant genetic resources should be viewed in term of gene pools. A wide range of methods of conservation would be needed to satisfy the needs of a gene pool. This calls for both *in situ* and *ex situ* conservation methods in saving species and genetic diversity from extinction. Conservation and research in biodiversity are not going to serve any meaningful purpose, unless significance of biodiversity is tagged to its financial benefits for mankind. Its utilization has to be in a very judicious, scientific and sustainable manner.

Sugarcane being vegetatively propagated crop could be preserved/conserved either through *in situ* conservation by formation of community seed villages, through active participation of the farmers or villagers who are the beneficiaries, or through *ex situ* in glass/ net house/conservation in the field gene banks. Alternatively, *in vitro* conservation methods like tissue culture can also be used.

Genetic resources of sugarcane

Sugarcane is known to be under cultivation in India from the Vedic times and India is considered to be one of the centres of diversity for *Saccharum* and allied genera . The genus *Saccharum* falls under group Saccharastrae of subtribe Saccharinae and tribe Andropogoneae, under the family Poaceae of order Poeales.

Desirable traits in different species of *Saccharum* species and related genera

Traits	***Species/Genus***
Sugar content, stalk thickness, low fibre	*S. officinarum*
Higher biomass, resistance to biotic and abiotic stresses	*S. spontaneum*
Resistance to multiple pests and abiotic stresses and for subtropical region	*S. barberi*
Resistance to multiple pests and abiotic stresses and for subtropical region	*S. sinese*
High yielding capacity, resistance to water logging, disease resistance and response to irrigation	*S. robustum*
Resistance to diseases, pests specially root parasites	*Narenga*
Disease resistance, cold tolerance	*Miscanthus*
Resistance to cold tolerance,soil borne nematodes	
Higher biomass and fibre	*Erianthus*

Utilization of sugarcane diversity

Adaptability and resistance had been introgressed from *S. spontaneum* (Coimbatore and Java forms) and *Erianthus* while sugar had been transferred from *S. officinarum*. Adaptability to sub-tropical climate of India came from *S. barber*. Kassoer, which itself is considered to be natural hybrid of the 'Cheribon' (*S. officinarum*) and 'Glagah' (the Javan form of *S. spontaneum* 2*n*=120). This natural hybrid Kassoer was used in a number of biparental crosses in early breeding programme to develop first generation hybrids (POJ 100) under nobilisation process.

The development of first commercial hybrid of sugarcane 'Co 205' in 1918 marked the success of interspecific hybridization programme[1, 2] taken-up by Barber in 1912. The process of development of new varieties derived from such inter-specific and sometimes tri-specific hybridization schedule gained momentum with this success. Varieties like Co 1148, CoJ 64, CoS 96268, CoS 8436, BO 91, CoSe 92423, CoJ 64, CoS 96268, CoS 8436, CoLk 8102, CoLk 8001 and CoS 767 possessing high yield, high sugar and adaptability for different agro-climatic zones of subtropical India made significant contribution in the country's GDP. Sugarcane breeders often use these varieties as parents in location specific breeding programmes. However, the good yield, adaptability and high sucrose content of some the newly developed varieties is also characterized by a narrow genetic base of the parents. This is a matter of concern and deserves detailed analysis.

These varieties are well adapted for sub-tropical conditions and they represent most of the diversity in form of high sugar (CoJ 64, CoS 96268, CoS 8436, CoLk 8102), high fibre (BO 91, CoSe 92423), early maturity (CoJ 64, CoS 8436, CoS 687), mid-late maturity (CoLk 8001, CoSe 92423, BO 91), thick canes (CoS 8436, CoLk 8001). But during 2009-10, a huge gap in demand and supply was created for sugar, due to low rainfall, and subsequent decrease in area and productivity. This lead to an abrupt increase in price of sugar and causing hardship for poor people. This suggested that varieties should be widely adapted and sustainable even under adverse situation. It is in such situations that the genetic diversity and its utilization assume significance. The utilization of biodiversity from gene pool for creating new variability for novel traits could help to overcome such problems to a large extent.

Diversity for livelihood and impact of sugarcane species (*Saccharum sps.*) biodiversity on poverty alleviation

Sugarcane and its species find mention even in our religious scriptures, with the various parts being used for different purposes. It has been mentioned in Ram Charit Manas written by Tulasi Das that Lord Ram used Kans as raw material for constructing his hut to live with his wife Sita and brother Lakshaman and also to weave mats, during exile. Even during the present day situations, sugarcane and its by-products serve as an important source of income to the people.

The income of rural people has been enhanced by deployment in agro-based industries like handicraft, jaggery (*gur and khandsari*) preparation. Survey in the areas of Dudhwa Natioal Park indicated that two artisan groups were identified from Dhyanpur and Barbata village of Sonaripur range of DNP for making hand fans, file folders, baskets, and mobile cover. The artisans, mostly women, prepare handicraft items from local grass varieties Kans (*Saccharum spontaneum*, Linn) and Bamboo (*Dendrocalamus strictus*). This wild species of sugarcane has been extensively used in making huts in warm areas and in resorts. Rural people use this species for making rope for their bed. Crushing of cane to extract juice by poor vendors in urban areas has given boost to generate some income and sustain their livelihood. The juice is also used for cooking some sweat meal like rice kheer. Table 1 clearly reveals the significance of various products and co products of sugarcane which could help in alleviation of poverty through better utilization of sugarcane biodiversity in form of cogeneration of energy from bagasse, alcohol from molasses as blending in petrol as non conventional means. Moreover bagasse ash is a good option for making papers.

Table 1: Various use of Sugarcane based products/ by products

Products/ By products	Uses
Sugar	Domestic Consumption
Gur	Domestic Consumption
Khandsari	Domestic Consumption, Confectionaries, Pharma ceuticals
Molasses	Industrial alcohol, glucose, fertilizer
Bagasse	Fuel for stove (*chulah*), Co generation of electricity, paper and paper boards, cattle feed,
Bagasse Ash	Construction industry, Chemical industry, Special types of glasses
Cane trash	Cattle feed, manures
Press Mud	Manures, wax industry, chemical, dairy and fish feed
Cane Tops	Cattle feed
Stubbles	As fuel in rural stove (*chulah*)

Community level activities include improvement of community livelihood skills through capacity building, training and providing alternate livelihood and market facilities, which must sustain the ecosystem in particular and environment as whole. About 488 sugar mills are engaged in processing of sugarcane to produce sugar and various co-products and give large amount of revenue in form of Indian and foreign currency. These industries have been also providing direct/ indirect employment to the various sections of society. Thus it has a great role in GDP growth of Indian economy. It is therefore imperative to conserve the biodiversity of sugarcane species as well as its related genera for present utilization and for effective use in adversity in future.

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