Sugarcane for Sustainable Agriculture and Food Production under Ambient Environment

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Sugarcane is a food-cum-cash-cum-industrial crop with high varietals resistance, anti-erosive and thus helps preserve biodiversity in tropical and subtropical zones. Sustaining sugar requirement as a source of food for an ever-growing world population in the changing ambient environment due to gradual depletion of natural resources, pollution, rising costs, low productivity and expansion of urban communities are some of the major challenges in the present century. Sugarcane and sugar productivity *per se* in many developing countries as well as Bangladesh, where sugarcane is growing, however, productivity is still remained far below than potential due to multiple abiotic environmental factors and socio-economic reasons. Due to high demand of cereals and vegetable crops sugarcane is being pushed to stresses (water-logging, flood, drought and salinity) prone marginal lands. Sugarcane as a long duration high in-put crop is facing enormous challenges and ardently waiting for productivity boost which is only possible through introduction of modern biotechnologies in its production-processing–diversification system. Bangladesh Sugarcane Research Institute developed stresses (water-logging, flood, drought and salinity) tolerant high yielding varieties of sugarcane and production technologies especially intercropping for sustainable production under ambient environment in particular agro-ecological and socio-economic conditions of resource poor farmers. Technologies for ancillary crops (Date-palm, Palmyra-palm, Palm-leaves, Stevia), jaggery (locally known as gur) and mushroom production on sugarcane bagasse as functional food have been developed as well as sugar beet adaptation is being tried to sustain sugarcane and sugar production. Sugarcane and sugar producing genetic resources are also being conserved. The aim of this paper is to attempt to present the potential of sugarcane for sustainable agriculture and food production as regards the environment as well as to discuss current status of sugarcane and sugar production as food given emphasis in Bangladesh.

Keywords: Sugarcane, Sustainable Agriculture, Food Production, Environment

Introduction

Bangladesh an agricultural country lies in the north eastern part of South Asia between 20˚34 ’ and 26˚38 ’ north latitude and 88˚01 ’ and 92˚41 ’ east longitude. The country is bounded by India on the west, north and northeast while Myanmar on the south-east and Bay of Bengal on the south. This is a land of 14.8 million hectare of which 9.1 million hectare is arable decreasing (1.0%) day by day due to urbanization and population growth (1.5%). Bangladesh enjoys generally a sub-tropical monsoon climate. While there are six seasons in year, three namely, Winter (November-February),

Summer (March-June) and Monsoon (July-October) are prominent and pleasant for crop growth as well as sugarcane. In Winter minimum and maximum temperature ranges from 7˚C - 13˚C and 24˚C - 31˚C respectively. The maximum temperature in Summer is 37˚C which occasionally rises up to 41˚C or more. Monsoon period accounts for 80% of the total rainfall (1429-4338 millimeter). Agriculture contributes about 22% to national Gross Domestic Product (GDP) and accommodates around 48.1% labour force (BBS, 2008). Due to climatic change stress prone areas (water-logging, flood, drought, salinity) are increasing, vulnerable for agriculture. Rice, Jute, Sugarcane, Potato, Pulses, Wheat, Tea and Tobacco are the principal crops. The country is now on the threshold of attaining self-sufficiency in food grain production.

Sugarcane is an important food-cum-cash-cum-industrial crop of Bangladesh covered 0.17 million hectare (2.05%) of arable land and shared 0.74% of GDP (BBS and DAE, 2008). Sugar industry as agro-based rural industry generated employment for nearly 17000 persons and more than 0.6 million farm-families are dependent on sugar industry for their subsistence. At present, 15 sugar mills are in operation under Bangladesh Sugar and Food Industries Corporation (BSFIC) with a capacity of 0.21 million tons of sugar production per year. The share of Bangladesh sugar market to world sugar market stands at only 0.2% (Alam *et al.*, 2008).

The aim of this paper is to attempt to present the potential of sugarcane for sustainable agriculture and food production regarding the environment as well as to discuss current status of sugarcane and sugar production as food given emphasis in Bangladesh.

Materials and Methods

Sugarcane and sugar production scenario of the world emphasizing Bangladesh were studied. The studies were covered of all sugar mills of Bangladesh. Data were collected mainly from secondary sources such as annual as well as other reports of Bangladesh Sugar and Food Industries Corporation (BSFIC), Bangladesh Sugarcane Research Institute (BSRI), Department of Agricultural Extension (DAE), Bangladesh Bureau of Statistics (BBS). Published and unpublished data were collected through personal communication. Published articles of different National and International Journals, Periodicals as well as Books and Internet Browsing were used to furnish information in the paper. Descriptive statistics and time series data were used to analyze the data recorded in the studies.

Results and Discussion

World sugar economy is facing a second consecutive year of a significant gap between consumption and production. The first forecast of world production of 159.04 million tons against expected consumption of 167.45 million tons projected deficit of 8.40 million tons (IAPSIT, 2009). In view of this, sugarcane for sustainable agriculture and food production under ambient environment is discussed given emphasis on Bangladesh.

Scenario of sugarcane, sugar and jaggery production

Due to increase of area under cereal and vegetable crops, sugarcane cultivation area is being decreased and pushed to stress prone (water-logging, flood, drought and salinity) less fertile marginal lands and river basins where no other crops are grown well. During the period of 1990-1991 to 2008-2009 average cultivation area, sugarcane, sugar and sugar including jaggery production experienced many fluctuations and were 168.31

thousand hectare, 6814.21, 164.47, 376.11 and 540.58 thousands ton respectively (Table 1). Mean production was 0.16 million ton far below than installed capacity of 0.21 million ton and the deficit was 0.77 million ton (46% of the internal demand). This huge deficit amount was met up by illegal border trade or either a lower per capita consumption of sugar or both. Although last few years importation of sugar increased tremendously due to improve economic profile of Bangladesh to meet up the required amount of sugar. Therefore, sugarcane for sustainable agriculture and food production demands due research, extension and management attention under changing ambient environment, and efforts are being taken in regards.

Table 1. Sugarcane, sugar and jaggery production, demand, supply and deficit.

Year (crushing season)	Sugarcane area (x000 ha)	Sugar production (x000 ton)	Sugar demand (x000 ton)	Sugar import (x000 ton)	Jaggery production (x000 ton)	Supply of sugar and jaggery (x000 ton)	Deficit (x000 ton)
1990-91	191.09	246.00	1425.00	138.00	432.00	816.00	609.00
1991-92	187.45	195.00	1448.00	5.00	482.00	682.00	820.00
1992-93	184.62	187.00	1472.00	64.00	415.00	666.00	806.00
1993-94	180.97	221.00	1530.00	86.00	334.00	641.00	889.00
1994-95	180.16	270.00	1559.00	156.00	285.00	711.00	848.00
1995-96	174.49	184.00	1587.00	28.00	371.00	583.00	1004.00
1996-97	175.71	135.00	1617.00	207.00	463.00	805.00	812.00
1997-98	175.30	166.00	1647.00	160.00	415.00	741.00	906.00
1998-99	174.09	153.00	1678.00	191.00	359.00	703.00	975.00
1999-00	170.45	123.00	1709.00	115.00	427.00	665.00	1044.00
2000-01	168.85	98.00	1716.00	328.00	436.00	862.00	854.00
2001-02	162.75	205.00	1729.00	210.00	306.00	721.00	1008.00
2002-03	165.99	177.00	1742.00	600.00	322.00	1099.00	643.00
2003-04	163.56	119.00	1757.60	440.00	371.00	930.00	827.60
2004-05	157.08	107.00	1781.00	687.00	462.00	1256.00	525.00
2005-06	152.63	133.00	1804.40	625.00	333.00	1091.00	713.40
2006-07	150.00	162.00	1827.80	594.00	310.00	1066.00	761.80
2007-08	130.00	164.00	1870.83	1200.00	299.00	1499.00	371.83
2008-09	153.74	80.00	1896.83	1300.00	324.00	1624.00	272.83
Mean	168.31	164.47	1673.56	375.47	376.11	903.21	773.10

Source: BBS and DAE, 2008; BSFIC, (1990-91 to 2008-09); Alam *et al.*, 2008.

Sugarcane breeding and biotechnology

BSRI has released 38 high yielding sugarcane varieties. Among these, four varieties (Co 527, Co 419, Co 1158 and Isd 34) have been introduced from abroad and one from (L-Jaba-C) local collection after evaluation. The variety Isd 26 is developed and released through mutation breebing. Rest of varieties have been developed and released through hybridization followed by selection. These varieties are being utilized for sugar and jaggry production. Chewing and juice varieties (Amrita and Isd 24) have also been developed for direct use as food. Development of parent materials and nobilization of varieties are being carried out. Since 1933 to date 1160 germplasms have been collected and are being maintained through *in-situ* conservation. However, main obstacles of variety development through hybridization are the non-flowering and/or non-synchronized flowering nature of sugarcane germplasms. Among 1160 only 200 germplasms are flowering.

Biotechnological tools are the alternate way of sugarcane improvement. Tissue culture protocols for plants regeneration via callus culture for somaclone selection and micropropagation have been optimized. Tissue culture derived somaclones are being incorporated in Preliminary Yield Trial (PYT) and Zonal Yield Trial (ZYT) for evaluation and formal release as varieties. Micropropagated plants are also being tested under field conditions for commercial production. Non-flowering somaclones from flowering parent and flowering somclones from no-flowering have been produced that are being utilized in breeding programme. DNA fingerprinting of all varieties has been completed for identification and protection. Genetic diversity analysis of varieties as well as germplasms are being carried out based on RAPD and SSR markers. Linkage mapping, QTL identification for Marker Assisted Selection (MAS) help sustainable variety development. Genetic transformation of salinity and drought tolerant genes in sugarcane varieties of Bangladesh has been optimized using *Agrobacterium*-mediated method. Transformed plants are being maintained under contained *in vitro* conditions.

Sugarcane physiology for stressful environment

Abiotic stresses such as water-logging, flood, drought and salinity are major problems for sugarcane cultivation. BSRI developed easy and efficient screening techniques and drought management practices such as trash mulching, leaf clipping and soil mulching under water-logged conditions for sustainable production. Germination problem under low temperature has been overcome. Sugarcane varieties Isd 20, Isd 32, Isd 34, Isd 35, Isd 36 Isd 37 and Isd 38 have been selected for cultivation under water-logging and flood conditions. Varieties Isd 20, Isd 35, Isd 36, Isd 37 and Isd 38 have been selected for cultivation under drought prone areas while Isd 2-54 and Isd 28 have been recommended for cultivation under salinity stress conditions. Sugarcane cultivation under stress prone areas where other crops production is not possible helps sustainable agriculture and there by increase of sugar and jaggery production as food.

Spaced transplanting (STP) technology

Low and irregular germination due to low ambient temperature and moisture stress during planting time (November to February) established sub-optimal crop leading to low yield. To cope with the low temperature and inadequate soil moisture STP technology has been developed. Sugarcane settlings are raised in nurseries for 6-8 weeks and then transplanted in the main field at uniform and optimal distances. This technology saves 60% seed cane, increase seed multiplication ratio (1 t 30), yield (50-80%) over conventional method and generate rural employments during lean period.

Intercropping for sustainable production and economic benefit

Sugarcane is a long duration (12-14 month) and wide spaced (one meter row to row distance) crop. Small holder subsistence farmers cannot wait for a long period to get return from a single crop. As a result, sugarcane faces serious competition with other short duration crops. To solve this problem BSRI developed a number of package technologies for intercropping with sugarcane in single row as well as in paired row planting system of sugarcane. In single row system intercrop is grown in between two rows of sugarcane. The paired row system provides two crops growing sequentially as intercrop between two paired rows of sugarcane. The intercropping system not only ensure higher crop production per unit area and time but also make viable to compete sugarcane cultivation with other short duration crops popular in the sugarcane growing areas of the country (Rahman *et al*., 2008).

Intercropping of vegetable such as potato, cabbage, broccoli, carrot, tomato bush bean, spinach and lettuce produced benefit cost ratios of 2.31, 2.41, 2.14, 2.92, 3.05, 2.53, 2.31 and 2.52 respectively while oil seeds mustard, linseed and soybean followed by mungbean gave benefit cost ratios of 2.00, 2.03 and 2.13 respectively in single row sugarcane, and paired row sugarcane with onion, garlic and coriander followed by mungbean showed benefit cost ratios of 2.61, 3.00 and 2.61 respectively compared to benefit cost ratio of 1.80 when sugarcane cultivated as sole crops.

Soil and fertilizer management

Recommended and updated fertilizer doses and management practices for sugarcane, ratoon cane and its intercrops for 12 Agro Ecological Zones (AEZs) where sugarcane is cultivated. Biological Nitrogen Fixation (BNF) in sugarcane (screening of sugarcane clones BNF-endowment) is being carried out. With the release of sugarcane varieties with BNF-endowment use of urea fertilizer will be decreased (>60%).

Sugarcane pests and diseases management

The research achievements in pests' managements include cultural, mechanical, chemical, biological control and Integrated Pest Management (IPM). Uses of resistant varieties, Moist Hot Air Treated (MHAT) seed cane and seed treatment are the contributions for controlling diseases resulting in considerable increase in sugarcane yield.

Jaggery a functional food production using botanical clarificant

Jggery is the semisolid food produced from sugarcane juice as well as juice from Date-palm, Palmyra-palm and Palm-leaves. Jaggey is healthier than sugar as it contained protein, fat, minerals, vitamins and others important elements. BSRI developed method of jaggery production using botanical clarificants and preservation techniques. Jaggery can be preserved for longer period in a painted earthen pitcher when the pitcher neck is sealed with wax. Granular form jaggery production techniques has been developed which is possible to preserve for longer period without deterioration. Syrup production from Date-palm juice and its preservation techniques developed.

By-products utilization

Traditionally sugarcane bagasse has been burned in boilers to produce energy for mills operations. The little portion of bagasse utilized has been put to other smaller uses such as paper production, mulch and for mushroom cultivation. Molases is used for cattle feed and distillery fermentation. Filter mud is used in the farm field as fertilizer. After harvesting green leaves are collected for animal feed and dry leaves are used as burning fuel, mulching material and fertilizer after decomposition.

Ancillary crops as alternate sources of sweetener

It is very difficult to meet up increasing demand of sugar and jaggery through increasing sugarcane yield, sugar recovery and bringing more area under sugarcane cultivation. So, should have to find ancillary crops as alternatives. Research, development and extension are being considered on Date-palm, Palmyra-palm, Palm-leaves for jaggery, juce and syrup production to sustain sugarcane cultivation and food production. Date-palm and Palmyra-palm cultivation in homestead, embankment, pond sides, road sides, off-shore and Palm-leaves cultivation in costal sea-shore are proven

alternatives. Stevia-an elite medicinal herb contained calorie free steviosides of 200-300 times sweeter than sugar could be cultivated in pots as well as homestead and field, and used as alternate source of sweetener for diabetes. Suitability of sugar beet cultivation under ambient environment is also being tested to sustain sugar and food production in Bangladesh.

Technology transfer activities

BSRI performs some activities pertaining to transfer of technologies. It has training programmes for trainers from sugar mills, Department of Agricultural Extension (DAE) and for advanced farmers; demonstration programme of matured technologies; programme for organizing field-days, farmers rally, seminar, workshop, group discussion and publications in the form of annual report, journal, leaflets, booklets, slide series, video film etc. Scientists attended `Agricultural Technical Committee (ATC)' meetings organized by DAE in different regions. BSRI scientists promptly visit any problem area and suggest remedies as and when required. A great success has been achieved in "Sugarcane based farming system research and development".

Sustainability of sugarcane research and extension

World Bank Agricultural Research Management Project (ARMP) findings, showed that the contribution of sugarcane research and extension investment was estimated as 16% Internal Rate of Return (IRR), which is higher than that of country's prime cash crop of jute. Findings of the World Bank studies reported that with the development of high sugar varieties and cultivation for sugar, jaggery, juice and chewing as food save foreign exchange which is the notable benefit for sustainable agriculture in Bangladesh.

Conclusions

Sugarcane ranking the second as cash crop and third among the major cultivated crops in the country is important for sustainable agriculture and food production having built-in potential for cultivation under stress prone ambient environment as only price ensured cash crop to the farmers of Bangladesh.

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