Vision 2030

Indian Institute of Sugarcane Research
Lucknow - 226 002

www.iisr.nic.in

भाकृअनुप
ICAR

Vision 2030

Indian Institute of Sugarcane Research

Raebareli Road, Post Office Dilkusha
Lucknow–226 002, U.P.
India

Printed : July 2011

Compilation & Editing : S.K. Duttamajumder, A.K. Sharma and
Brahm Prakash

Published by Dr. R.L. Yadav, Director, Indian Institute of Sugarcane Research, Lucknow - 226 002, U.P., India. Printed in India at Army Printing Press, 33 Nehru Road, Sadar Cantt, Lucknow. Tel. 2481164

सत्यमेव जयते

डा. एस. अय्यप्पन
सचिव एवं महानिदेशक
DR. S. AYYAPPAN
SECRETARY & DIRECTOR-GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद्
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 114

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN, NEW DELHI 110 114
Tel. : 23382629, 23386711; Fax : 91-11-23384773; E-mail : dg.icar@nic.in

Foreword

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all of the institutions of ICAR, have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

Sugarcane supports one of the largest agro-processing industries of India and more than 6 million farmers are engaged in its cultivation. Besides, about half a million skilled and semi-skilled workers, mostly from rural areas are also engaged in the sugar industry. By 2030 AD, India will require nearly 33 million tonnes of white sugar for domestic consumption alone. Production of alcohol for partial replacement of fossil fuel and use of bagasse in co-generation of electricity have great potential in future and thus requirement of cane will increase further. With an average sugar recovery of 10.75 per cent, about 520 million tonnes of sugarcane will have to be produced and this will entail an increase in sugarcane productivity to the tune of 100 to 110 tonnes/ha, as area may stabilise around 5 million hectare. The Indian Institute of Sugarcane Research (IISR), Lucknow has developed several technologies to enhance sugarcane productivity in the country and has to gear itself to address new challenges to ensure sustainable sugarcane production in future as well.

It is expected that the analytical approach and forward looking concepts presented in the '*Vision 2030*' document will prove useful for the researchers, policymakers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

(S. Ayyappan)

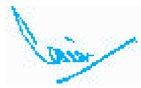
Dated the 6th July, 2011
New Delhi

Preface

The stabilisation of production and productivity of sugarcane is important in view of the rising internal consumption of sugar and its need for ensuring adequate exports. The prospect of sugarcane as a future renewable energy crop for ethanol production, due to its increasing use as a fuel blend in the automobile sector in addition to the cogeneration of electricity, has got the further boost. It is estimated that by 2030 AD., India will require about 520 million tonnes of sugarcane. To meet this emerging challenge, a proper planning and sustained efforts are needed to achieve the target in spite of the shrinking available resources. Keeping all this in mind, the *Vision 2030* has been prepared outlining the road map. While developing this document, the suggestions received from members of Research Advisory Committee of the Indian Institute of Sugarcane Research have also been taken into account.

I wish to record my sincere thanks to Dr. S. Ayyappan, Director General, ICAR and Secretary, DARE for inspiring us to develop the Vision document and to Dr. Swapan Kumar Datta, Deputy Director General (Crop Science) for his active involvement and to Dr. N. Gopalakrishnan, Assistant Director General (Commercial Crops) for his active participation in the discussion and kind suggestions.

Dr. S.K. Duttamajumder, Head, Div. of Crop Protection and Dr. A.K Sharma, Principal Scientist and I/c, Research Co-ordination & Management Unit have put in considerable thought and efforts and have done a commendable job in shaping the *Vision 2030* deserve special thanks. My sincere thanks are also due to all the scientists and Heads of Divisions of IISR, who have provided new ideas and discussed various issues threadbare to shape the future of this Institute for the next two decades. I am equally grateful to the members of Research Advisory Committee for their valuable and thought provoking suggestions and guidelines to improve upon the future course of IISR. Assistance rendered by Mr. Brahm Prakash in bringing this document to the present shape is highly appreciated.



(R. L. Yadav)
Director

Dated the 1st July, 2011
Lucknow

Preamble

Sugarcane occupies an important position in agrarian economy of India. About 6 million farmers and a large number of agricultural labourers are involved in cane cultivation. Besides, more than half a million skilled and semi skilled workers, mostly from rural areas are engaged in the sugar industry, the largest agro processing industry of India. The area under sugarcane is hovering around 4.4 million hectares and with an average productivity of 68 tonnes/ha. The highest production of 355 million tonnes of cane has been achieved during 2006-07 crop season from 5.15 million hectares. On an average, white sugar production accounts for nearly 60 per cent of the total cane produced in the country, 15-20 per cent sugarcane is utilized for *gur* and *khandsari* production and rest is utilized for other purposes including seed.

During 2009-10 crop season, sugar factories have produced 18.91 million tonnes of sugar. With per capita consumption of white sugar at 22 kg/annum, and the estimated population of 1.50 billion by 2030 AD., the consumption of white sugar may be increased to 33 million tonnes. It is estimated that by 2030 AD., about 520 million tonnes of sugarcane with average sugar recovery of 10.75 per cent (60 per cent cane will be utilized for white sugar, and 15 per cent will go for ethanol production) will be required. This will entail a productivity requirement of 100-110 tonnes/ha, as the area under sugarcane cultivation may stabilize around 5.00 million hectares.

Keeping in view the yield and recovery patterns of sugarcane during the last 25 years, the target is a stiff one, and it needs proper planning and judicious use of the available resources to achieve it. Intensive research efforts are, therefore, required to bring about this change in both cane quality and productivity.

On an average, Uttar Pradesh commands 46 per cent of the cane acreage and 40 per cent sugarcane production. Thus, the onerous task of increasing the productivity rests squarely on Uttar Pradesh. In fact, the Indian Institute of Sugarcane Research based in Lucknow is working to this effect since its inception in 1952. The average cane yield of India has increased from 40.5 tonnes/ha

(1950-51) to 70 tonnes/ha (2009-10), and recovery has gone up from 10.03 per cent to 10.20 per cent during this period, whereas in the same period, average yield of Uttar Pradesh has gone up from 39.48 tonnes/ha (1950-51) to 59.2 tonnes/ha (2009-10).

The Indian Institute of Sugarcane Research, Lucknow was established by the erstwhile Indian Central Sugarcane Committee in February 16, 1952 for conducting research on fundamental and applied aspects of sugarcane culture as well as to co-ordinate the work done on this crop in different states of India. The Government of India took over the Institute from the Indian Central Sugarcane Committee on January 1, 1954. On April 1, 1969, it was transferred to the Indian Council of Agricultural Research (ICAR). Subsequently, Headquarters of the All India Coordinated Research Project on Sugarcane was added.

Since its inception, the Institute has been working towards the upliftment of cane agriculture in India, in terms of quality, productivity, management practices and various policy issues related to production of sugarcane and sugar. The previous efforts in this direction were strengthened by preparing "IISR Vision 2020" towards the end of the 20th Century and "IISR Vision 2025" at the initiation of XI Five year Plan.

'IISR Vision 2030' document presents key challenges and opportunities in the sugarcane sector in the next two decades for developing an appropriate strategy and a road map to articulate role of the Indian Institute of Sugarcane Research, Lucknow in shaping the future of the sugarcane research in India for growth, development and equity in cane agriculture.

Contents

Sugarcane Scenario

At present, 115 countries of the world cultivate sugarcane for sugar production and produce about 133 million tonnes of sugar which is three fourth of the total sugar production (169 million tonnes) of the world. Remaining sugar comes from sugarbeet. Sugarbeet cultivation and processing is highly subsidized in the European Union, which contributes nearly 21.5 per cent of world sugar. With the WTO agreement in place, sugarbeet cultivation may not remain a profitable proposition in European Union due to drastic reduction in subsidies on its production and processing. In this situation, the shortfall in sugar may be compensated by sugarcane producing countries like Brazil, India, China, Pakistan, USA, Australia, Thailand, Philippines, etc.

India is a major producer as well as consumer of the sugar in the world and during 2009-10, it produced 18.9 million tonnes of sugar, which was nearly 11.8 per cent of the total sugar production of the world. In India, there are two distinct zones for sugarcane cultivation, tropical-south and subtropical north. Subtropical north while comprising 60 per cent of total cane area contributes only 48 per cent to total cane and 37 per cent to total white sugar production in the country. The lower cane productivity and sugar recovery in subtropical north zone is the main cause of variation between the zones. The average cane productivity in subtropical north zone was 54.7 and 56.4

tonnes/hectare in comparison to 81.9 and 80.8 tonnes/hectare in tropical south zone (2009-10 and 2010-11, respectively).

According to estimates of the National Commission on Agriculture (1976) and estimations by various agencies, the population of the country is expected to swell to 1.5 billion by 2030 AD at the present compound growth rate of 1.6 per cent per annum. It is estimated that the per capita consumption is likely to increase and may go up to 35 kg (both white sugar and *gur*) by 2030 AD. At this rate of consumption and expected rise in population, the country may require nearly 52 million tonnes of sweeteners by 2030 AD. With decreasing trends in *gur* and *khandsari* production, the demand for white sugar is likely to increase to 33 million tonnes by 2030 AD. The emerging energy need of ethanol for blending in petrol will require additional sugarcane over and above the cane requirement to produce 33 million tonnes of sugar. In order to meet the growing demand of sugar and energy by 2030 AD in India, around 520 million tonnes of sugarcane with a recovery of 10.75 per cent will be required (312 million tonnes of cane exclusively for white sugar and additional 78 million tonnes of cane exclusively for ethanol production).

The emerging scenario of sugarcane as the renewable energy crop in India for the production of ethanol, as a supplement to the fossil fuel is providing enough scope to increase the sugarcane production further. Due to its renewable energy potential, sugarcane has become the preferred choice, since the Brazilian venture in early 1980's in the production and utilization of ethanol as fuel blend with petrol for running automobiles. Brazil has made a major stride in this direction and presently diverts 50 per cent of its sugarcane for ethanol production.

In India, molasses, a by-product of sugarcane processing for sugar, will remain the main raw material for ethanol production. Bagasse, the other by-product of sugar processing will continue to remain as the basic raw material for co-generation of power in sugar mills. In fact, by 2030 AD it is visualized that every sugar mill in India will be modified as the energy-producing hub in the rural sector, giving boost to the rural economy thereby playing a major catalytic role in the socio-economic transformation of rural population.

India has to gear up to the new challenges of higher cane and sugar production to meet the future requirement. With the present trend of sugarcane and sugar production, India will hardly be able to meet 75 per cent of the projected requirement. Therefore, a sustained effort is needed to increase the present trend of cane production to such a level that India becomes a sugarcane surplus country.

Sugarcane and economy

Sugarcane occupies a very prominent position on the agricultural map of India covering large areas in sub-tropics and tropics. It is the sole raw material for the largest agro-processing industry in the rural sector, wherein about 6.0 million growers cultivate this crop. Besides, the industry also provides employment to half a million people in the rural sector. In 2009-10, there were 490 sugar mills in the country in operation in comparison to just 139 mills in 1950-51. The industry pays about Rs.39,000 crores annually to growers for the cane they supply and contributes Rs. 2,200 crores to the central exchequer, besides contributing Rs.1100 crores to the State Governments.

Sugarcane is a multi-product crop and has immense potential for diversification. Beside the production of sugar, green top of sugarcane is used as fodder for milch cattle; similarly molasses, a by-product of sugar processing is also used as a cattle feed. The enormous fuel potential of sugarcane is being utilized by both sugar mills and *gur* and *khandsari* processing units. Bagasse, the left over ligno-cellulosic material after the extraction of juice, is used as fuel for boiling the juice and running the boilers for co-generation. In fact, it is the bagasse that has made the sugar mill a self-sustained unit in terms of energy requirement. The filter mud, another by-product of sugar processing is utilized as manure. Moreover, sugarcane in the prevailing cropping systems is one of the most important crops that has sustaining capacity to maintain soil health and crop productivity. Despite being heavy feeder of soil nutrients, sugarcane with its high root mass improves soil condition. Beneficial associations of microorganisms with sugarcane roots also help in this direction. Association of beneficial microorganisms like *Acetobacter* (helps in nitrogen fixation, growth promotion), Mycorrhiza (P solubilization and increased nutrient availability) helps in sustaining the soil fertility and reduces the dependence on chemical fertilizers. Hence, the research and development focus is needed to develop and promote those technologies that raise farm income and ensure employment opportunities.

A distinguishing feature of the Indian sugar industry is that the number of cane growers linked to factories is very large. Transport of cane is arranged through tractor trolleys, hired trucks or railway wagons. Due to change in the policy of the State, sugar factories can operate within a radius of 15 km and thus, it will reduce transportation cost of cane, otherwise required to bring cane from long distance. This will improve in fresh cane supply to the mill and thereby will improve the sugar recovery. Liberalization of Govt. sugar policy has attracted more private players in sugar production and this has provided needed impetus to increase the capacity of existing sugar mills and also to commission new sugarcane mills. It is expected that new sugar factories will be able to meet the future challenge in the production of sugar, ethanol and power. In sub-tropics, marketing is arranged through Co-operative Cane Unions that help farmers in marketing sugarcane and other developmental activities. In tropical states, there is a direct contact between the factories and farmers for cane marketing. It allows maturity-wise harvesting and proper development of the crop.

In sugarcane cultivation, the major policy decision, *i.e.*, fixing of fair and remunerative price (FRP) is taken by the Union Government and subsequently, some State Governments also fix its price, *i.e.*, (State Advised Price, SAP). This pricing mechanism helps farmers in getting better price for their cane produce. The perpetual problem of delayed payment of cane arrears, many a times, acts as strong deterrent in the augmentation of cane acreage and cane development. This leads to a cyclic pattern in the sugarcane production in India. Adequate and good quality of cane supply to sugar factories throughout the season has remained a perpetual problem. In order to ensure stability in cane supply position, there is a need to study the policy framework that regulates sugarcane and sugar production so that corrective measures could be taken to stop wide fluctuations in production.

One of the inherent weaknesses in the present price policy is that cane growers are not adequately rewarded for the quality of cane supplied to the mill. In the past, efforts were made to introduce a system of payment of cane price according to the actual sugar content of cane supplied by each grower. Due to very small farm holdings, a large number of farmers are involved in the supply of cane to a factory; hence, practical difficulties come in the way of introducing such a system. Considering the situation, greater reliance has to be placed on varieties with high sugar content and high yield, which alone would help in improving sugar productivity.

Need for vertical growth

The acreage under sugarcane from 1980-81 (2.67 m ha) to 2009-10 (4.18 m ha) has increased at an average compound growth rate of 2.15 per cent per annum. There is hardly any possibility of additional area forthcoming under sugarcane, primarily due to decreasing availability of arable land. Sugarcane is also facing stiff competitions from food grains, oilseeds, pulses and other high value crops including vegetables in the share of area due to continuous rise in their prices. In view of these, it may not be possible to maintain the same growth rate of area and it may stabilise around 5.00 million hectares by 2030 AD. It is apparent that, in future, the production target of sugarcane has to be met mainly by increasing the productivity and quality of the crop. The productivity of cane during period from 1980-81 to 2009-10 has increased at an average compound growth rate of 1.07 per cent per annum. The average productivity level needs tremendous boost and it should touch 110 tonnes/ha mark by 2030 AD.

Rich germplasm diversity

Natural variability in the form of germplasm is one of the most important and basic raw materials at the disposal of the sugarcane breeders for meeting the future needs of crop improvement. India has the world collection of sugarcane germplasm and it is being maintained by Sugarcane Breeding Institute, Coimbatore. The cultivated and wild species of *Saccharum* namely, *S. officinarum*, *S. barberi, S. sinensis, S. spontaneum* and *S. robustum* along with related genera which can hybridise with sugarcane *viz*., *Erianthus, Miscanthus, Narenga* and *Sclerostachya* are the basic genetic resources of sugarcane. In India, a total collection of 4803 clones is being maintained. Out of this collection, about 2070 are basic germplasm at species level, the rest being Indian and foreign hybrids and allied genera. Thus, at the national level enough variability is available in the country for improvement of sugarcane. Sugarcane freely flowers and produces viable seed in tropical climate of Coimbatore/Kannur and Sugarcane Breeding Institute, Coimbatore is one of the two pioneers in sugarcane breeding in the world. In fact, Coimbatore bred varieties have ruled sugarcane scenario of many countries, including USA and South Africa.

Despite the fact of rich diversity and availability of world collection of sugarcane germplasm, India is still to tap this potential to its advantage. Limited utilisation of basic germplasm (at the species level) in India has, over the years, narrowed down the genetic base of the commercial cane varieties and the plateauing effect has become apparent in terms of sugar recovery and cane productivity. Out of 2070 clones available at species level, hardly 50 have been utilised in the breeding programme. Further, out of 764 *S. officinarum* (noble cane, the main contributor of genes for sugar) clones available at SBI, hardly 100 accessions flower in nature, and out of which, only 23 have been utilised in breeding programmes, so far. It is imperative to tap the huge available genetic potential to break both sugar and yield barriers.

Vegetative propogation and scope for biotechnology

Sugarcane is a highly heterozygous polyploid crop and for all commercial purposes, it is propagated vegetatively using stalk cuttings called 'sett'. Due to its high heterozygosity, the resultant F_1 obtained after crossing of the desired parents provides enough variability for an early selection. The vegetative propagation aids in hassle free maintenance of hybrid vigour of F_1 over clonal generations. Another advantage of sugarcane is its capability in giving rise to a stubble crop after harvest of the plant crop. This reduces the cost of cane cultivation in terms of land preparation, cost of seed and costs incurred in planting.

The clonal propagation has inherent weakness of accumulation of cryptic pathogens and pests over time, which severely impairs the productivity potential of a genotype. A large number of sugarcane varieties were gradually phased out due to various biotic (outbreak of diseases like red rot, varietal decline) and abiotic stresses. Sustaining sugar productivity at the existing level necessitated quick replacement of the cane varieties. The field stability of varieties always remained a major issue in the cane production. Even if suitable replacement is available, considerable time elapses before it covers sizeable area, primarily on account of limited availability of healthy seed, due to slow rate of seed multiplication in sugarcane.

Varietal improvement through conventional methods has shown its limitations in increasing both sugar and imparting red rot resistance in the commercial cane genotypes. Biotechnological opportunities now need to be exploited to the fullest extent to produce transgenic plants having these traits. A special maintenance garden is essential to understand and realize the exact potential of a cane genotype. Research on cryo-preservation of vegetative buds, thus, needs to be taken up in order to cope with any environmental hazard. Tissue culture and meristem culture may provide some opportunity in removing the cryptic pathogens in addition to thermotherapy (MHAT).

Sugarcane production system

In India, more than 6.0 million farmers are engaged in sugarcane cultivation and majority of them are small and marginal with very small land holdings and 50 per cent of the total area under sugarcane is comprised of holdings between 0.5 to 5 ha. For 20.7 per cent of the area, holding size ranges between 5 to 10 ha. This has provided a unique advantage for better land use through intercropping and increase in the input use efficiency. High value and remunerative crops like vegetables, potato, oilseeds and pulses offer great scope for growing as intercrops and in further providing additional income and reducing risks in the long duration crop of sugarcane as well as in improving land use efficiency.

Monoculture of cane has resulted in substantial reduction in productivity. The proper sequence of cropping such as sugarcane and leguminous crops as a component of system approach of nutrient management, is suitable for sustainable productivity. Sugarcane based cropping systems generally are at least of 3-4 years duration. The plant crop of sugarcane is invariably followed by its ratoon crop. Mostly one to two ratoons are taken in succession. However, the crop preceding sugarcane and succeeding its ratoon crop varies in different agro-climatic conditions and under socio-economic situations. Sugarcane based systems are well integrated with rice-wheat and rice based cropping systems. The major sugarcane based cropping systems are: Rice-wheat/mustard-sugarcane plant-first ratoon-wheat (rice-wheat-sugarcane) and Maize-wheat-sugarcane plant-first ratoon-wheat (sugarcane-wheat) in UP, Cotton-sugarcane plant - first ratoon - sorghum in Maharashtra, groundnut-sugarcane in Gujarat and Rice-sugarcane plant - first ratoon (sugarcane-rice) in Western and South India. Majority of the crops in the sugarcane based cropping systems are exhaustive in terms of nutrients and the place for pulses and green manure crops for improving soil productivity is very less in the system. Sugarcane fits well into the predominant rice-wheat cropping system of the Indo-Gangetic plains and in the absence of sizable extent of leguminous crops in this system, sugarcane seems to be behaving like a pulse crop in maintaining the soil bio-physical properties. Sugarcane based cropping systems are better in terms of infrastructure and socio-economic development indicators such as the value of agricultural output per ha compared to other cropping systems. Thus, it offers great opportunity to study and quantify the beneficial effects of the sugarcane based systems on soil fertility and productivity.

Ratoons

In sugarcane, ratoons occupy a sizable proportion of the total area under cane cultivation, upto 50% of cane area in sub-tropical states like Uttar Pradesh. Ratoons are poorly managed in India. The major advantage of ratoons lies in its early maturity, lower cost of cultivation and high sugar recovery during early period of crushing. The contribution of ratoon yield to total cane production is around 30% since the yields are reduced due to several factors like variety, soil, irrigation, poor ratoon management etc. The main causes include formation of toxic substances in the rhizosphere, upward shifting of root system, lesser physiological capacity for nutrient uptake, and decline in the soil nutrient status. The ratoon management involves stubble shaving, gap filling, additional nutrient supplementation, biochemical manipulation using growth regulators and mulching etc. Better ratooning ability can be achieved by scheduling the varieties with minimum rate of yield decline in successive ratooning as against a plant crop, use of thin and medium thick varieties as against thicker varieties. Deep rooted drought tolerant types possess better ratooning potential. Varieties with early and profuse tillering, less tiller mortality and high shoot population are the characters associated with better ratooning. Organic manuring also increase the cane yield and juice quality in multiple ratoons.

Water requirements

For the normal growth and yield of any crop, it has to be provided with optimum soil moisture conditions throughout its growing period. It is more so in a crop like sugarcane where the end product is cane yield which comprises about 70% water. Both physiologically and compositionally, water is the major constituent of cane. It has been worked out that to produce one tonne of cane, 200 to 250 tonnes of water is required, more so under tropical conditions. Depending on the yield level of the crop and the climatic conditions prevailing in different parts of the country, the water requirements vary considerably from 1200 to 3000 mm and is high in view of its long occupation in the field and to


Skip furrow method of irrigation

sustain the large biomass it produces. Sugarcane consumes 6.46% irrigation potential of the country whereas it occupies only 2.55% of the net cultivated area. The total consumptive use of water varies from 200 to 250 cm during the crop period. However, the actual requirement of water varies from place to place depending upon the climate, soil condition, crop duration and method of application. Ideally 35-40 irrigations are required for a crop of 12 months duration in tropical area compared to 6 to 7 irrigations under sub-tropical conditions. In many cases, 30-40 irrigations are hardly possible, which invariably affect the crop yield. The common method of irrigation followed for sugarcane is the surface irrigation, either by flood or through furrows. However, the irrigation efficiency of surface irrigation is only 30-50% and there is considerable wastage of water. Micro irrigation and water use efficient cultivation techniques become relevant in this context, for conserving water and optimizing its use.

Abiotic and biotic stresses

In the tropical region, sugarcane gets more or less ideal climatic conditions for its growth. It is cultivated with better package of practices and higher irrigation levels. The growing season is long with more equitable and favourable conditions. Floods, waterlogging, diseases such as red rot are the main problems for sugarcane cultivation in the region. Moisture stress during the early part of the cane growth mostly during March to June, is an important problem. Smut is an important disease affecting sugarcane production in this region particularly in the plateau region. In the coastal areas, red rot has become a major threat. Among the pests, early shoot borer, particularly in the late planted crops, and woolly aphid are considerably serious in this region. In sub-tropical region, the extremes of climate is the characteristic feature. During April to June, the weather is very hot and dry and the temperatures are extremely high. December and January are the very cold months with temperature touching sub-zero levels in many places. The major portion of the zone *i.e.,* the North-West zone comprising the areas in Haryana, Punjab and Western U.P., has very low temperature in December-January which often causes frost. Because of extremes of weather, the active sugarcane growth is restricted to 4-5 months


Internal symptoms of red rot

only. In eastern U.P., Bihar and West Bengal, sugarcane suffers due to floods and waterlogging during monsoon months. Several pests and diseases, particularly red rot and top borer and pyrilla are common and serious. The cane yields are lower in the sub-tropics due to short growing season, moisture stress, more pest and disease problem, floods and waterlogging, delayed planting after wheat and very poor ratoons. The management of these stresses will necessitate the development of better cultivation and integrated diseases and insect-pests management modules.

Labour scarcity and scope for mechanization

Human labour is an important input factor in sugarcane production. The participation of human labour is seen right from preparatory cultivation to harvesting. Being a long-duration crop of 12 months and its sowing spreading from October to May, sugarcane is a labour intensive crop, which requires about 250 to 400 labour mandays per ha. Most of the cane operations are carried out manually and the use of machinery is limited only for field preparation. The human labour costs constitute more than 50% for labour intensive sugarcane crop. Inter-culture operation is the single largest consumer of labour in sugarcane cultivation in India as it requires at least 5 interculture operations including manual weeding operations. The other main components of labour use in sugarcane cultivation are harvesting and planting operations. Harvesting requires about 70 mandays per ha for a normal sugarcane crop. In case of planting which consists of two operationally different but sequentially connected labour intensive operations of sett preparation (seed cane cutting, transportation of seed cane, seed preparation of 2-3 eye-budded setts & seed treatment) and sett placement (distribution of setts, opening of furrows, placement of setts in furrows by following appropriate geometry, application of fertilizers, covering of setts and pressing of soil), it requires about 50-65 mandays on an average. Considering a lot of pressure on labour demand for harvesting and sowing of other competing crops as well as diversion of labour to the rural development schemes like MGNREGS, there is a need that appropriate and cost-effective machines are developed for its use by the farmers. This in turn imparts great scope for mechanization of cane agriculture.

❑

Sugarcane Research System

The country is endowed with an effective Research and Development network to adequately cater to the needs of sugarcane growers and sugar industry in the country. India has two central research institutes fully devoted to sugarcane improvement and cultivation and one institute for sugarcane processing. Besides, every state has its own sugarcane research and development wing. In the non-governmental sector, two institutes are also in operation, meeting the immediate need of associated farmers and sugar mills. The All India Coordinated Research Project on Sugarcane provides platform for multilocation testing of sugarcane varieties and technologies developed by the different research Institutes/SAUs. Varietal development programme is undertaken at 22 regular centres and 15 voluntary centres across the country. In view of lack of flowering in sub-tropical states, hybridization programme is located at SBI, Coimbatore, and the true seed is supplied to all the 22 centres. The progenies generated from these crosses are evaluated at the respective centres and location specific varieties are identified based on their performance at the locations. Through this decentralized programme, a large number of locally adapted varieties have been developed which are suitable for different parts of the country.

The schematic presentation of the research and development set-up in India is given below:

Central Government

Ministry of Agriculture

- Indian Council of Agricultural Research (ICAR), New Delhi
- Indian Institute of Sugarcane Research, Lucknow
- Sugarcane Breeding Institute, Coimbatore
- Directorate of Sugarcane Development, Lucknow
- National Sugar Institute, Kanpur

State Governments

- Cane Development Departments
- State Sugarcane Research Stations
- State Agricultural Universities

Sugar factories

- Cane Development wings of Sugar factories

Non-Governmental Organization

- Vasantdada Sugar Institute, Pune
- Karnataka Institute of Applied Agricultural Research, Sameerwadi, Karnataka

❑

IISR (Lucknow)-2030

The Indian Institute of Sugarcane Research has been working towards the upliftment of the cane agriculture in India since its establishment. It now envisages to march ahead with renewed vigour to face complex challenges and to harness domestic and global opportunities for the welfare of the cane growers in India and become sensitive to the needs of its stakeholders.

Vision

An efficient, globally competitive and vibrant sugarcane agriculture

Mission

Enhancement of sugarcane production, productivity, profitability and sustainability to meet future sugar and energy requirements of India

Mandate

- To conduct basic and applied research on all aspects of production and protection techniques of sugarcane and sugar crops.
- To work on breeding of varieties for sub-tropical region in close collaboration with Sugarcane Breeding Institute, Coimbatore.
- To develop linkages with State Agricultural Universities, Research Centres and other organizations for collaborative research, exchange of information and material.
- To provide training, consultancy and advisory services to farmers, industries and other users at regional, national and international levels.

Focus

To accomplish the vision and mission of the IISR and to achieve the desired growth in area, productivity and recovery of sugarcane in different agro-ecological zones of the country and to extend appropriate information and technologies to the end users, following three key issues have been identified which need to be pursued at:

- Low levels of cane yield and sugar recovery
- High cost of cane cultivation
- Decline in factor productivity

These issues will be addressed by adopting following strategies and programmes :

I. *Increasing the levels of cane yield and sugar recovery*

- Introgression of untapped genes in the parental gene pool
- Enhancing selection efficiency through marker aided selection (MAS)
- Improving sink strength and source efficiency
- Enhancing productivity of ratoon cane

II. *Reducing the cost of cane cultivation*

- Nutrient efficiency through rhizosphere engineering and INM technology
- Water use efficiency through micro- irrigation
- Land use efficiency through companion cropping
- Reducing pesticide use in an eco-friendly manner through bio-intensive IPM and IDM
- Mechanizing sugarcane farming

III. *Arresting the decline in factor productivity*

- Soil biological and nutritional dynamism
- Carbon sequestering through cropping system

❑

Harnessing Science

The current (2009-10) average cane productivity in the sub-tropical belt is 56.4 tonnes/ha (maximum productivity of 65.12 tonnes/ha in U.P. was achieved in 1997-98) and it has to be raised to the tune of 90 tonnes/ha by 2030 AD. Similarly, in the tropical belt, the cane productivity has to be raised to 125 tonnes/ha from the present level of 80.8 tonnes/ha. The onerous task of increasing productivity of cane lies more in the sub-tropical north zone, as it accounts for nearly 60 per cent of the total cane acreage of the country. Considering the limited scope for further expansion in cane area, the maximum area under sugarcane may stabilize around 5.00 million hectares by 2030 AD. Hence, the possibility lies in increasing the cane productivity and recovery of sugar. It may be safely estimated that the productivity in the next 20 years may touch 110 tonnes/ha with a sugar recovery of about 10.75 per cent and diversion of about 40 per cent sugarcane to other uses including seed, energy (alcohol), *gur* and *khandsari*, etc.

The Indian Institute of Sugarcane Research would strive to harness power of science in increasing productivity, enhancing input use efficiency, reducing cost and post-harvest losses, minimizing risks and improving quality of cane through conventional techniques as well as new science and tools. The Institute would evolve/help in evolving a mechanism for accelerating innovations through institutional and policy support. In the present context, technological challenges are becoming more complex than before as demand for sweeteners is increasing and supply sources such as area under cane is remaining static. Incidentally, the science is also changing rapidly with the emergence of new tools, methods and approaches that promise technological breakthroughs to accomplish the mission, as per the details given below:

Varietal improvement

Natural variability in the form of germplasm is one of the most important and basic raw materials at the disposal of the breeders for meeting the future needs of crop improvement. India has the world collection of sugarcane germplasm and it is being maintained by Sugarcane Breeding Institute, Coimbatore. A total collection of 4803 clones is available. Out of this collection, about 2070 are basic germplasm at species level, the rest being Indian and foreign hybrids and allied genera. Thus, at the national level enough variability is available in the country for improvement of sugarcane. Sugarcane freely flowers and produces viable seed in tropical climate of Coimbatore/Kannur. Sugarcane is a highly heterozygous polyploid crop and for all commercial purposes, it is propagated vegetatively using stalk cuttings called 'sett'. Due to its high heterozygosity, the resultant F_1 obtained after crossing of the desired parents provides enough variability for an early selection. The vegetative propagation aids in hassle free maintenance of hybrid vigour of F_1 over clonal generations. The genetic base of the commercial cane genotypes has to be broadened to improve their stability in different agro-ecological situations. It is imperative to evolve high sugar and high yielding varieties.

Biotechnological interventions

The research activities need to be reoriented for evolving high sugar, high yielding and location specific sugarcane varieties with enhanced potential to withstand the various biotic and abiotic stresses. This could be achieved by utilising tissue culture tools and biotechnological innovations.

In recent years, many genes and gene products have been identified which get induced upon exposure of plants to various biotic and abiotic stresses. Genes encoding enzymes of the biosynthetic pathways of different osmolytes such as proline, glycine betaine, sorbitol, pinitol, have been cloned in India and exploited in improving abiotic stress tolerance. Also, genes encoding the enzymes and proteins involved in scavenging the reduced oxygen species such as super oxide radical (O^-), hydroxyl radical (OH), and hydrogen peroxide (H_2O_2) need to be evaluated in sugarcane germplasm. Osmotin, choline oxidase and annexin need to be utilized in gene transfer and evolution of transgenics for drought tolerance.

Improving Physiological efficiency of sugarcane

Sugarcane takes about 40-45 days for germination after planting and thus, in this respect, it is a physiological inefficient crop. The research efforts are required to reduce the germination time from 40-45 days to at least 20-25 days. The efforts are thus required to enhance the physiological efficiency of sugarcane through modulating the expression of sucrose metabolizing enzymes for high sucrose accumulation.

Seedcane Technology

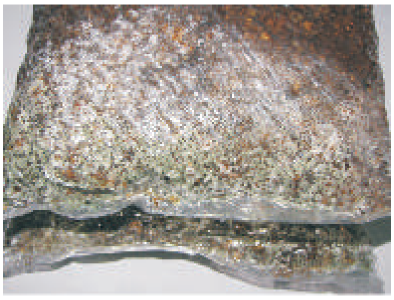
The requirement of seedcane is quite high for planting by conventional methods. It is about 6 tonnes per hectare. High seedcane use entails problems to cane growers in respect of its transportation to the site of planting. The research efforts are needed to develop technologies that ensure significant reduction in the use of seedcane per hectare and lead to 100% germination. There is also a need to put more seed technological efforts for developing proper packaging and transportation models for transporting seedcane to long distances at farmers' fields.

Abiotic stresses management

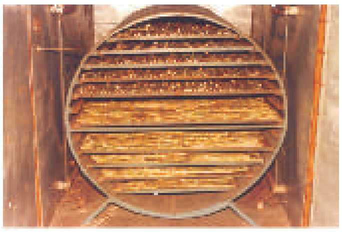
In tropics, the non availability of water coupled with summer drought aggravates the stress effect and eventually lower the crop yields. The problem of short term drought is common in rainfed agriculture which normally accounts to substantial loss in productivity. Thus, the yield of a variety under stress is its response to stress and inherent yield potential. Increased yield under stressful environments can be obtained by modifying cultural practices or by selecting genetically improved varieties. These cultural practices are costlier alternatives. A slow but long term and ultimately less expensive objective is to develop stress resistant genotypes. Of late, chemical modification of the plant to enhance the resistance potential to environmental stress is a possibility that is currently being investigated. Plant growth regulators offer scope for stimulation of growth, timely induction of metabolic reactions, and modification of internal water relations, and resistance to environmental stresses. The plant breeders will need large populations of diverse germplasm for making selections to achieve or to build desirable traits in present day varieties.

Biotic stresses management

The major diseases of sugarcane like red rot, wilt and cryptic disease like RSD have spread to newer areas and genotypes. In the absence of effective control measures, life span of high sugar varieties will be shortened and thus, will hinder the stability of sugarcane production. Moreover, diseases like red



Trichoderma mixed culture - a potent bioagent rot and wilt are the major bottlenecks in the development of high sugar cane genotypes, as high sugar content often reduces the level of resistance of a cane genotype to these diseases rendering the cane breeding more difficult and cumbersome. Major emphasis need to be provided for resistance breeding coupled with the development of low cost bio-control technology.


Heat treatment of cane

The increasing use of chemicals for controlling insect-pests is expected to change the beneficial fauna of the soil and also the bio-agents that may naturally control the insect-pests population. Therefore, it is important to increase the level of resistance to these insects introgression of resistance genes from the wild relatives, marker assisted selection, genetic engineering and pyramiding of resistance genes using molecular approaches.

Increasing cane productivity

The overall productivity level as reflected by current growth rate is not enough to attain the desired level of cane production. Keeping in view the limitations of area under sugarcane, productivity level needs to be increased to the tune of 110 tonnes per hectare by 2030 AD. This will require more emphasis on developing and disseminating input use efficient agro-technologies at a faster speed.


Ring pit method


Ratoon Management Device

Ratoon crop productivity has to be augmented by improving stubble-bud sprouting during sub-optimal temperatures in December and January. Suitable agronomic practices have to be evolved to increase both cane length and thickness of the summer crop, whose tiller population could be compensated by reduced row spacing. Integrated nutrient management schedules need to be worked out for sugarcane as part of a larger cropping system.

Keeping in view the reduced availability of water resources, there is an urgent and imperative need to enhance water use efficiency on all fronts, like improving the methods of irrigation, water conservation and the ways to utilize poor quality water. The same is required for the chemical fertilizers to enhance nutrient use efficiency. A judicious and balanced use is a must to sustain the soil health and cane productivity. Renewable biofertilizers have enough promise in future to reduce dependence on costly chemical fertilizers making cane agriculture more remunerative and eco-friendly.

Mechanization of sugarcane agriculture

To mitigate the labour scarcity, timely farm operations along with the reduction in human drudgery, mechanization of cane agriculture from planting and interculture to harvesting and loading is a must. Mechanisation will also improve the overall energy use efficiency of the sugarcane based farming.

Raised bed seeder

Post-harvest management

Emphasis needs to be given on initiating multi disciplinary and multi stakeholder research for minimizing post harvest losses in cane as the cut to crush period is too long resulting in considerable sucrose losses in cane. Strategies in terms of developing small scale processing units of *gur* and *khandsari*, using conventional and non-conventional resources of energy also need to be developed.

Energy production

Production of alcohol for partial replacement of fossil fuel and use of bagasse in co-generation of electricity have great potential in future. This in turn will lead to more demand of cane, and sugar mills will come forward in a big way to boost cane production to reap this opportunity. This will give rise to a new type of research demand to support enhanced ethanol production.

❑

Strategy and Framework

To achieve the desired growth in area, productivity and recovery of sugarcane in different agro-ecological zones of the country and to extend appropriate information and technologies to the end users, following issues and strategies have been identified which need to be pursued at (Details in Annexure - I).

Strategies

- Developing high yielding, disease resistant and pest tolerant, good ratooning, input responsive sugarcane varieties
- Designing and developing planting methods, planting geometry, biotic and abiotic stress management modules and integrated nutrient supply system for maximizing yield of plant and ratoon crops
- Evaluation of genetic resources in sugarcane (*Saccharum* germplasm) for sustainable sugar yield for biotic and abiotic stresses
- Improving quality seed production
- Developing integrated pests and disease management modules
- Increasing physiological efficiency of sugarcane varieties for biomass and sugar
- Design and development of technologies for mechanising sugarcane cultivation
- Bio-intensive management of red rot and borers
- Maintenance of soil health through carbon sequestration to balance nutrition requirement, sustain high cane yield and sugar recovery
- Minimising post-harvest sucrose loss

- Harnessing the power of emerging and frontier areas of science like biotechnology, bioinformatics, product diversification, etc., in sugarcane
- Developing sugarbeet agro-technologies
- Providing training, consultancy and advisory services to farmers, industries and other stakeholders
- Quantifying and mitigating the effect of climate on yield and quality of sugarcane.

Epilogue

The IISR is committed to bring a demand driven and technology-led enhanced growth in cane agriculture in the country for improving livelihood opportunities and ensuring sustainable cane agriculture. The Institute firmly believes that the path of sugarcane research and development followed through enhancement of sugarcane production, productivity, profitability and sustainability will help in meeting the future sugar and energy requirement for ever rising population of India. The Institute is committed to boost sugar productivity per unit area and time. The Institute envisions that innovations made would break yield barriers and transform the cane agriculture into an efficient, globally competent and vibrant one. As extension in sugarcane is mill-centred, the Institute will carry out its technology transfer operations through developing a mechanism to disseminate the technical know-how and by conducting user friendly training programmes. It will also rope in private manufacturers to help it in manufacturing and fast multiplication of its machineries and equipments and also for exploiting the commercial use of these technologies.

Concerted efforts would be made to transform the Indian Institute of Sugarcane Research to be more sensitive to the need of the cane farming community, especially of the smallholders. Intensive research and development efforts made so far would be better utilized to provide a base for developing new strategies and programmes in a time frame mode. The Institute will carry out its research programmes in participatory mode by becoming more vigilant and by developing a culture of responsibility, accountability and integrity in the sugarcane research.

The Institute has requisite modern facilities and is all set to share its research facilities and professional manpower with other national and international agencies/institutions working for the cause of sugarcane development in India.

❑

References

- Anonymous (1997) Vision-2020 : IISR-Perspection Plan, Indian Institute of Sugarcane Research, Lucknow. 57 p.

- Anonymous (2007) Vision-2025, Indian Institute of Sugarcane Research, Lucknow. 62 p.

- Anonymous (2011) Vision-2030, Indian Council of Agricultural Research, New Delhi. 24 p.

❑

Annexure – I : Strategic Framework

Strategies	Approach	Performance measure
Developing high yielding, disease resistant, pest tolerant and input responsive sugarcane varieties	• Evaluation of genetic resources (*Saccharum* germplasm) for sustainable sugar yield for biotic and abiotic stresses • Germplasm evaluation for high yield, high sugar, red rot resistance and better ratoonability • Development of parental lines for high yield, red rot and top borer resistance and better ratoonability • Identification of molecular markers including ESTs for red rot resistance and other biotic stresses, high sugar accumulation and abiotic stresses • Conventional breeding for desired traits using the developed parental lines • Marker assisted breeding for high sugar, early maturity, red rot resistance and ratoonability • Survey, surveillance of major diseases and insect pests • Characterization of variability both at host and molecular level and identification of potential pathotypes for testing of cane genotypes • Strategy for location specific disease and pest resistance breeding and their deployment • Screening of germplasm of sugarcane and allied genera for resistance • Identification of DNA fragment/gene sequence responsible for resistance to major diseases/pests • Screening of breeding population/selections against major diseases and insect pests • Development of quick method of detection of resistance in cane genotypes through molecular markers • Evaluation of morpho-physiological parameters in relation to source and sink strength in sugarcane • Identification of physio-biochemical basis for abiotic stress and markers with breeding value related to these characters • Role of sucrose phosphate synthase, sucrose synthase and invertase activity • Physio-biochemical basis for early maturity and high sucrose accumulation • Identification of physiological markers with breeding value • Transcript analysis of sucrose metabolization and photosynthesis associated genes • Gene expression profiling related to sugar content and their validation	• Screened and evaluated genotypes • Developed and released varieties

Designing and developing planting methods, planting geometry and integrated nutrient supply system for maximizing yield of plant and ratoon crops	• Designing planting techniques aimed at efficient nutrient use • Inclusion of legumes, recycling of crop residues, factory wastes and biofertilizers in sugarcane based cropping systems • Improving nutrient use efficiency through elucidation of location and variety specific nutrient requirement of sugarcane based cropping system • Nutrient fixation and release in soil and uptake potential of cane genotypes with special reference to N, P, K, Ca, S, Zn, Fe and Mn • Design, development and refinements of the various types of sugarcane planters developed at IISR • Design and development of planting equipments for emerging planting methods and planting geometries • Development of equipments for precise application of fertilizer and pesticides	• Developed input efficient crop modules and planting techniques
Improving quality seed production	• Breeder seed production • Maximization of seed cane multiplication rate using micro –propagation, single bud technology, etc. • Nutrient management for production of quality seed cane • Frequency and quantity requirement of irrigation water at different crop stages • Evaluation of microbial bio-agents for improving germination and plant growth • Evaluation of plant-based bio-pesticides, chemicals, etc., for improving germination, plant growth and induced resistance • Elucidation of critical range of nutrient and PGRs for better sprouting and establishment • Development of a heat therapy equipment for bulk scale treatment	• Quantity of quality seed cane produced and distributed to farmers and sugar mills
Increasing physiological efficiency of sugarcane varieties for biomass and sugar	• Assessment of total aerial biomass and dry matter partitioning • Early canopy development to increase LAI • Identification of physiological parameters for predicting yield and sugar • Impact of low and high temperatures on juice quality and sugar recovery	• Physiological parameters identified and process analysed
Quantifying and mitigating the effect of climate on yield and quality of sugarcane	• Collection of long-term weather database from different states growing sugarcane • Establishing correlation of yield and quality with different weather parameters • Identifying critical weather parameters in specific crop phases affecting yield and quality • Deciphering the effect of climate/weather variability and crop management practices on yield and quality of sugarcane • Source-sink dynamics at elevated temperature and CO_2 concentration	• Development of database and management practices

Developing bio-intensive integrated management of red rot and borers	• Identification and characterization of bio-agents against red rot and borers • Bio-efficacy of bio-agents and induced resistance against red rot and formulation of IDM modules • Standardization of delivery system • Mass production of bio-agents • Identification of alternative hosts for the parasitoids • Development of laboratory rearing technique for mass multiplication of bio-agents/parasitoids • Biodiversity in *Trichogramma chilonis* and *T. japonicum,* and identification of potential strain(s) • Evaluation of synthetic sex pheromones and application techniques for management of borers • Development of bio-intensive IPM modules for insect-pests and rodents	• Developed disease and insect pest management modules
Balancing nutrition requirement to sustain high sugar recovery	• Role of nutrient interactions in sugar recovery • Effect of nutrition scheduling on sugar recovery	• Developed nutrient management modules
Advancing maturity and minimising post- harvest sucrose losses	• Sucrose accumulation in relation to internodal enzymes • Assessment of cane quality and sugar content in response to applied maturants • Quantification of sucrose losses due to inversion, etc., after harvesting of cane • Use of anti-inversion and biocidal compounds and bioagents to minimize post-harvest losses • Minimizing post-harvest sucrose losses through RNAi appraoch • Developing equipments for application of bioagents and biocidal compounds	• Quantification of sucrose losses
Improving rhizospheric environment and enhancing nutrient use efficiency	• Carbon sequestration in sugarcane based cropping systems • Crop residue recycling • Introduction of legumes in cropping systems • Rhizosphere bio-engineering • Increasing input use efficiency in sugarcane based cropping systems • Rhizospheric influence on physiological efficiency and C &N flux dynamics of sugarcane • Design and development of equipments for residue incorporation	• Enhanced carbon sequestration
Mechanising sugarcane cultivation	• Design and development of appropriate and energy efficient machinery for sugarcane planting, interculture and harvesting in different agro-climatic zones	• Designed and developed prototypes / machines

Enhancing input use efficiency and reduce use of costly inputs like pesticides	• Technology for multi-ratooning. • Development of remunerative sugarcane based cropping systems • Development of microbial consortia for efficient nutrient uptake • Accelerating *in situ* decomposition of crop residues for quick release of locked-in nutrients • Efficient use of irrigation water • Integrated weed management in sugarcane based cropping systems • Intensive use of bio-agents against diseases • Bio-intensive management of major insect pests of sugarcane • Evaluation of nutrient and water use efficiency • Application of PGRs on plant and ratoon crops • Estimating magnitude of applied nutrient use • Precise application of irrigation water through automation • Developing suitable irrigation system for emerging planting methods and geometries	• Improved input use efficiencies
Enhancing productivity of ratoon cane	• Optimizing shoot population through agro-techniques • Designing efficient fertilizer schedule and application methods • Integrated management of water, weeds, pesticides • Designing suitable planting technique for multi-ratooning • Development of integrated pest and disease management schedules with use of antagonists and biopesticides. • Physio-biochemical basis of poor stubble sprouting under low temperature condition • Physical and chemical methods to improve sprouting • Development of an engine/tractor operated equipment for ripping, earthing-up and fertilizer application system for ratoon crop	• Enhanced ratoon cane productivity in sub-tropics • Developed improved planting techniques and modules
Create quality human resources to address emerging challenges	• Training the available manpower in the emerging and frontier areas like biotechnology, plant molecular biology, bioinformatics, etc.	• Improved research efficiency • Qualified manpower in cane research
Training sugarcane development personnel, farmers, etc., and consultancy to the sugar industry	• Organization of training programmes on sugarcane production, protection and management to farmers, cane development personnel, extension workers and to those interested in sugarcane cultivation. • Demand based consultancy to the sugar mills.	• Trained extension personnel and farmers • Enhanced sugar productivity at mill level

Sugarbeet improvement and development of agro-technologies	• Development of high yielding and tropicalized varieties of sugarbeet • Development of agro-techniques and plant protection measures • Development of seed production technology • Design and development of equipments for sugarbeet cultivation • Physio-chemical intervention for high growth, sucrose and control of post-harvest losses	• Increased area under sugarbeet cultivation
Improving production and marketing efficiency	• Ex-ante and ex-post economic evaluation of sugarcane production technology • Forecasting parameters of sugarcane and sugar production • Identification of production and marketing constraints • Pricing policies for sugarcane and its end products. • Development of transportation models • Reducing cost of sugarcane production for boosting farmers' income and sugar exports as well	• Analysed scenarios and policies related to sugarcane production and marketing

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch