

Sugarbeet:

An alternative crop for bio-ethanol production in India

Ashutosh Kumar Mall*, Varucha Misra, Sangeeta Srivastava and Ashwini Dutt Pathak

ICAR–Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh 226 002

Bio-ethanol as well as bio-energy production is becoming an important part of the whole world. Primary biomass production in India is the major source for production of bio-ethanol. In this aspect where sugarcane crop is already playing its part, sugarbeet crop is an emerging source for bio-ethanol production. Sugarbeet crop is a tropical crop but with the positive effect of the breeders, it is now grown even in sub tropical parts too. With the upcoming new policies, this crop has made its way to a progressive path. From many years, this crop has been used as a source of fodder for animals like cattle, especially in summers when there is scarcity of green fodder but for the upcoming enhanced need of bio-ethanol production as well as sugar production in India for mankind, this crop has emerged as a good and effective source for bio-ethanol production.

Keywords: Bio-ethanol, Crude oil, Fossil energy, Sugarbeet

CRUDE oil has always been the main source for energy consumption but energy demands have gradually increased with the increasing population rate and industrialization over past many years. This increasing energy demand is not solely met up by the crude oil production, rather alternative sources for ethanol production are also the need of the day. About 90 billion litres of ethanol and 21 billion litres of biodiesels per year are estimated for production of bio-fuels globally. Besides, the use of prevailing sources for energy production has been well known for causing harmful effects not only on our environment but even causing hazardous effect on human health. For instance, fossil energy causes greenhouse gas emissions (GHGs), burning of petroleum-based fuels causes the increase of atmospheric CO₂ level and

so on. So, with the increasing requirement of energy, it is necessary to find a source which is clean, eco-friendly as well as renewable for energy production at industrial and consumer levels. This causes high requirement of alternative sources for energy production. In this regard, bio-ethanol production is smart and an eye-catching option. In the existing scenario, bio-ethanol either

from bio-energy crops or from ligno-cellulosic biomass has a great potential and thus attained an important position as transportation fuel instead of use of gasoline as a fuel. The usage of bio-ethanol as a fuel for vehicles enhances the oxygen content leading to improved oxidation of hydrocarbons along with fall in content of aromatic compounds as well as in atmospheric emission of carbon monoxide. Furthermore, the production of carbon dioxide in this process is compensated by the absorption process of carbon dioxide by the plants in their various stages of growth for their process of photosynthesis, to overall circumvent the total carbon dioxide emission. Worldwide expansion in the production of bio-fuels is at present one of the existing issue on the agenda of agriculture and



Sugarbeet

food research. On one way it is an increased source of income as an addition to food product.

Sugarcane juice as well as its molasses are the main raw materials for production of bio-ethanol, however, its long duration growth cycle and boon and burst condition of its production emerges the need of other alternative sources for production of bio-ethanol. It is here where sugarbeet crop makes its stand as a supplementary crop for sugarcane. The reason behind is its short-duration of 6–7 months (as compared to 10–12 months of sugarcane), high sugar content of 15–17%, 12–14% of high sugar recovery and 85–90% purity. This crop has full potential to act as a bridge between prevailing sugar production and anticipated national sugar requirement. Furthermore, sugarbeet crop apart from being sugar producer has other valuable utility, for example, green sugarbeet top is good cattle feed, molasses obtained from sugarbeet processing is an economical product which has the potentialities as an export material and is also of great utility in fermentation industry. This makes the crop occupy an important place in the sugar economy of the country.

Sugarbeet is a crop that has the potential of withstanding the various climatic and soil conditions as well as tolerant to two abiotic stresses, i.e. salinity and frost. Being naturally bestowed with tolerance to these stresses it helps to bring several hundred hectares of uncultivable land under cultivation, particularly, in the present scenario this area is estimated to be around 6.7 million hectares. The crop can also help to enhance the factory crushing season and consequently encourage employment to many people. As it matures in the month of April, it enables the sugar mills to process both the raw materials (sugarcane and sugarbeet) subsequently during their high crushing season, thus enhancing the mill efficiency. Also, combined agricultural and manufacturing economy is an added benefit of this crop. In farmer's point of view, sugarbeet is an important for three main reasons, *viz.* firstly, a

dependable cash crop; secondly, amelioration of salt-affected soils with encouraging soil fertility through sound farming practices and thirdly, by-products obtained from crop, especially green tops is a nutritious cattle feed during the hot months of the year when green fodder is not readily available.

Status of sugarbeet research in India

In 1970's and 1980's, intense research was carried out in germplasm evaluation, varietal development, agronomical, pathological, entomological and agricultural engineering aspects on sugarbeet. The crop was a success with the farmers and the factory. It had a commercial run of over thirty years when the factory was closed due to reasons not exclusive to sugarbeet. One of these, however, was the trade liberalization which closed the remunerative disposal of sugarbeet molasses to a Mumbai-based pharmaceutical company. It may be borne in mind that this was made possible without the best available varieties. Sugarbeet has been shown to be agriculturally feasible under Indian conditions. It has the potential to yield comparable to sugarcane in half the time with water saving of 30–40%. In early 2000s, many southern states were reeling under consecutive droughts leading to insufficient cane supplies to the factories. At this juncture, some multinational sugarbeet seed companies came out with tropicalized sugarbeet varieties and a need was felt to conduct feasibility trials. The results showed that sugarbeet could be grown productively from the months of October–November to April–May. The history of sugarbeet development started from Sriganganagar (Rajasthan), where the extra canal water for every acre of sugarbeet grown was a big attraction along with the assured purchase of sugarbeet by the sugar factory. Such sorts of incentives are still the need of day for promoting this crop. Besides, being an economical crop, an agreement for the timely procurement of the entire produce has to be in place. Furthermore, support for availability of seeds,

fertilizers and pesticides along with technical guidance in raising the crop has to be provided from time-to-time. The variable types of soil as well as wide range of variation in climate from place to place in our country is supporting the seed production of this crop making us self reliant on this crop.

The increasing demand of seed production for this crop has attracted several Multinational companies to India for reducing the seed cost. Presently, some work is being performed at Sriganganagar among farmers, factory and seed companies. Thus, this crop can become an agricultural reality.

Attractive features of Sugarbeet crop

- Short duration crop of 5–6 months
- Naturally bestowed with tolerance towards salinity and frost
- Well adapted for saline and alkaline soils
- High sucrose content, purity as well as high sugar recovery
- Green tops as a nutritious cattle fodder.

For integrating sugarbeet with the existing cropping pattern, a lot of efforts have been performed in this field but still some more research is needed for the new locales as well as emerging it as a “crop of choice” for ethanol production. The recent development in this aspect is the intercropping technique wherein sugarbeet is chosen as an intercrop with sugarcane, thus, increasing sugar productivity per unit time and area as well as enhancing 50–55% of farmers benefit.

Seed production in India by IISR

The sugarbeet plant develops a large succulent tap root in the first year and a seed stalk in the second year. Sometimes due to unfavourable conditions, the plants give out seed stalk in the first year itself, technically termed as bolting. Usually sugarbeet root crops are planted in the spring and harvested in the autumn of the same year. For seed production, however, an overwintering period of cold temperature of 4–7°C (vernalization) is required for the root to bolt in the next growing season and for the reproductive stage

Table 1. Mean performance of varieties/germplasm at multi-location

Variety	Root Number '000/ha	Single root weight (Kg)	Sucrose (%) April/May	Root yield (t/ha)	Gross sugar (t/ha)
Shubhra	89.5	0.59	17.6/18.7	64.6	11.66
Cauvery	88.0	1.11	14.8/16.9	94.4	14.97
LS 6	94.0	0.66	14.9/16.7	69.9	10.96
R 06	88.0	0.67	14.7/16.2	71.7	11.03
IISR Comp 1	90.0	0.77	14.9/16.6	61.9	9.75
Indus	86.0	0.76	15.5/16.5	74.7	11.87

to be initiated. Standardization of sugarbeet seed production was done under Indian conditions at altitudes above 50,000 amsl, such as Mukteswar and Ranichauri, Auli, Shimla and Kalpa, Darjeeling and Srinagar for the diploid Russian Variety, Ramonskaya-06 (R-06). Other varieties, such as, IISR Comp-1 and LS-6 developed by Lucknow and Pant S-10 by Pantnagar centers were also tried in a limited way. Indigenous diploid varieties developed and recommended for general cultivation in India with high temperature (40-45°C) tolerance varieties were maintained. Foundation seed production was standardized and routinely carried out by the Kalpa center in Himachal

Pradesh and then mass multiplied by National Seeds Corporation. It may be mentioned here that these seeds were all obtained from multi-germ varieties and the seed supplied to the farmers was un-pelleted.

Sugarbeet normally requires more than a year to produce a seed crop. Roots of about 200-250 g require a photo thermal induction from 80-110 days at a temperature ranging from 3°C to 10°C. Production of seed has been achieved in a year in India by sowing seeds in June/July and allowing four and a half months old crop. A thermal induction, from mid November to February in hills is provided for flowering induction. After getting the required thermal induction during winters, flowering

stalks come out in March/April and the seed can be harvested by July.

Two methods of seed production are commonly used.

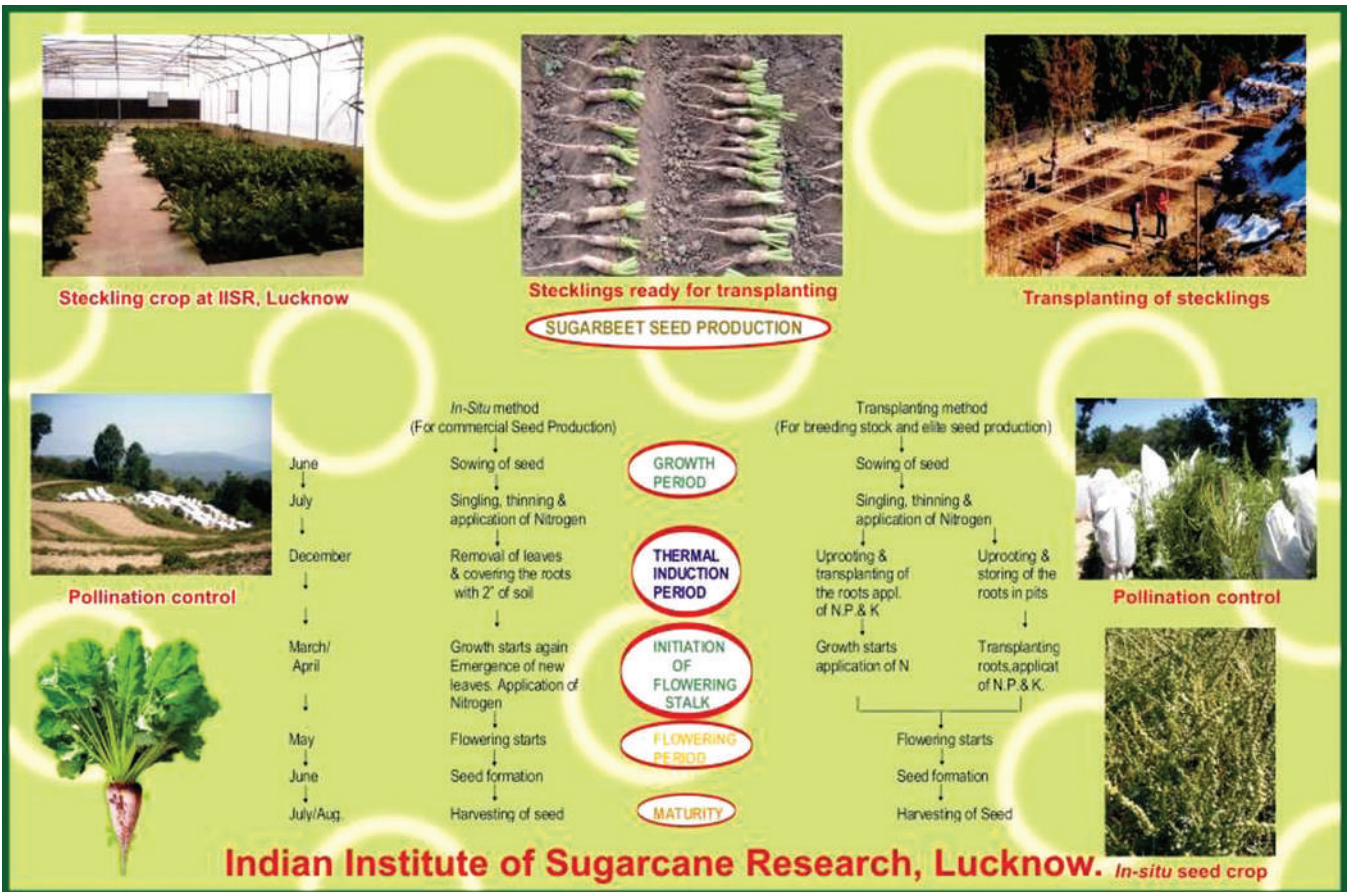
In situ method: The roots are left as such in the field after covering with little soil for overwintering. This method is generally used for the production of certified seeds.

Transplanting method: Selected roots which are either transplanted in December or roots spread into trenches for overwintering and transplanting during March. This method is generally used for the production of foundation or elite seed.

For transplanting of roots, row-to-row spacing is kept at 50 cm while plant-to-plant spacing is kept at 30 cm. After the thermal induction is over in February, fertilizers *i.e.* N 240 kg (spilt in two doses), 80 kg P₂O₅ and 80 kg K₂O per hectare are given. A good crop gives a seed yield of 16-18 q/ha.

Importance of bio-fuels in India

With each day passing by, biomass



Methods of seed production

Table 2. Ethanol obtained from various agricultural crops

Production	Ethanol yield of some agricultural crops					
	Sugarbeet	Wheat	Triticale	Rye	Corn	Potatoes
Total Production (million tonne)	27.8	21.4	4.1	4.1	3.3	13.1
Average yield (t/ha)	61.7	7.2	5.6	4.9	9.2	43
Ethanol yield (m ³ /ha)	6.62	2.76	2.23	2.03	3.52	3.55
Ethanol yield per kg	0.11	0.38	0.40	0.41	0.38	0.08
Energy yield (MJ/ha)	155,570	64,860	52,405	47,705	82,720	83,425

energy is becoming an important and essential part of the global renewable energy contributing a handsome amount of share to increasing share of the electric production all over the world. In India, the production and consumption of biomass at primary level has been the main resource of energy. According to the reports of Integrated Energy Policy of the year 2006, about 80 mt is currently being used in households of the rural area. In India, production of renewable energy using biomass as a raw material is always at frontline due to the fact that large availability of different types of feed stocks particularly agricultural wastes. The projects on this basis will be sustainable with a feasible business model. The three major sources for bio-ethanol production all over the world are sugar, starches and lingo-cellulose. In India, Molasses obtained from sugarcane in the sugar mills is the most commonly used raw material for its production. However, in past, there is scarcity of proper policy in the area of purchasing and blending of ethanol due to which not many of the distilleries although having the capacity and potential to produce ethanol were not producing it.

Bio-ethanol is a high octane number bio-fuel which is produced from fermentation of corn, potatoes, grain (wheat, barley and rye), sugarbeet, sugarcane and vegetable residues. A comparative evaluation of ethanol obtained from various

agricultural crops is given in Table 2. The amount of ethanol produced from bagasse is more in case of enzymatic process (0.238 Kg ethanol/Kg bagasse) than the two-stage dilute acid process (0.186 ethanol/Kg bagasse) clearly indicating the superiority of enzymatic process. The research work is being investigated the possibility of producing ethanol from sugarbeet, which is widely cultivated in western country and its potential contribution to bio-fuel uses at mixtures of 5-10%.

In general, ethanol production from sugarbeet involves conversion of saccharose into monosaccharide which later gets converted to ethanol by the process of fermentation. By this method of obtaining ethanol, one liter of ethanol is produced from 3 to 3.5 kg molasses. The production of ethanol may be either from molasses or directly from the cane juice. The former is a by-product of sugarcane obtained after sugar processing. Although production of ethanol from this crop requires higher cost than petrol but there are many advantages to use it as a fuel. The advantages of using bio-fuels at rate of 5% in mixtures are as follows:

- Enhances the rural economy
- Provides higher added value by producing 10–15% more sugarbeet than that at present
- Provide benefits to other sectors using by-products
- Economic benefits of agricultural and the other inputs trading
- Decreasing of foreign dependency

on imports as producing renewable fuels locally

- Reduces atmospheric emissions

Future strategies and challenges

Efforts should be considered towards a way to develop a technology for high yield of quality sugarbeet. Being vital for its chemical properties, care should be given to the roots of the crop so that their capability to produce sugar is not hampered by the cultural characteristics. Even for the flourishing commercial use of sugarbeet, there should be efficient sugar processing technology available in sugar mills especially favourable to our indigenous factories. Critical studies on the economic aspects, needed to further confirm and preliminary findings regarding the economic viability of the crop in the country and profitability to farm and industry, would be of great value for beet development in the country. This crop has an edge in salt-affected areas and crop has potential for profitability if grown for bio-ethanol production. The farmers would get better returns on growing sugarbeet than wheat. They would also have the advantage of an assured market under a contract farming mechanism with the sugar mills and supervised agronomic practices. To encourage the farmers to bring more area under sugarbeet crop, IISR has taken initiative in introducing sugarbeet in Bihar also with sugar factories with diffusion plants. IISR has organized one National consultation, one summer school for researchers and one IISR-Industry interface with researchers, industries of sugar, bio-ethanol and seed for scientific footing and popularization of this crop in India.

*Corresponding author e-mail: ashutoshkumarmall@gmail.com

Pradhan Mantri Krishi Sinchai Yojana

This Yojana brings

- Per Drop More Crop
- Inputs from MoWR and DOLR received
- Increase in agricultural production and productivity and enhance farm income.