

Production and Processing of Tropical Sugarbeet in Bangladesh

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ABSTRACT

A series of experiments were conducted at BSRI Farm, different sugar mills and saline areas of the country during 2011-2012 cropping season to evaluate the performance of two tropical sugarbeet varieties (Shubhra and Cauvery). Results of the experiment on sugarbeet varieties with different sowing times and locations revealed that variety Cauvery showed better performance than Shubhra in respect of different yield contributing parameters. Among the sowing dates, November sowing provided significantly higher yield compared to December. In November sowing Cauvery produced 82.33 t ha^{-1} whereas Shubhra produced 75.77 t ha^{-1} . In case of late sowing (December), yield of sugarbeet variety Cauvery and Shubhra were 74.33 t ha^{-1} and 71.67 t ha^{-1} , respectively. No significant difference on pol percentage of beet was found in different times of sowing. In all locations (14), the variety Cauvery yielded higher ($54.34\text{-}135.85 \text{ t ha}^{-1}$) than variety Shubhra ($51.87\text{-}121.03 \text{ t ha}^{-1}$). Among the locations, Shyampur had the highest yield for both of the tested varieties (Cauvery: 135.85 , Shubhra: 121.03 t ha^{-1}) while Natore produced the lowest. Results of intercropping with sugarcane clearly indicated that both the varieties of sugarbeet under different row arrangement produced satisfactory yield as well as pol percentage of beet. There was no adverse effect on beet yield and pol percentage in saline prone area, where salinity level was $4\text{-}14 \text{ dS/m}$ during growing period. Sugarbeet processing requires several steps, including washing, slicing, diffusing, juice purification, evaporation and crystallization. Sugarbeet juice extraction is different from that of sugarcane. In the present study, all these operations were made by locally manufactured machineries and extracted juice was used for semi-solid and granular goor production. Considering physical and chemical properties, quality of jaggery (goor) was found satisfactory.

Key words: Tropical sugarbeet, beet yield, pol % beet, goor making

INTRODUCTION

Sugar is an important food for human being. Continuous supply of sugar is essential for brain functioning. As per FAO recommendation (13 kg sugar per person per annum) Bangladesh requires about 2 million tons of sugar per year but the present domestic production is about 0.6 million tons (0.1 million ton sugar and 0.5 million tons jaggery) (Rahman, et al. 2006). Sugarcane and sugarbeet are mainly used for producing white sugar. In Bangladesh only sugarcane is being used to produce sugar and goor but the areas and production of which is decreasing day by day for different reasons. So the deficit can be minimized through cultivation of another important sugar crop like sugarbeet.

Sugarbeet (*Beta vulgaris* L.) is an important sugar crop. Sugarcane and sugarbeet produce 65-70% and 30-35% of world white sugar, respectively. Sugarbeet

belongs to the family *Chenopodiaceae*. It is native to Mediterranean area (Asia Anterior) where it was cultivated as far back as about 200-500 BC (Anonymous, 2006). Sugarbeet is a temperate crop, generally grown in Europe, North America and temperate zones of Asia. According to FAO, France, Germany, USA, Russia and Ukraine are the major sugarbeet producing countries of the world. Recent achievements of research were the development of suitable varieties for sub-tropical and tropical agro-climatic conditions. Sugarbeet was also found to be suitable for saline soil though that cannot be used for other agricultural purposes. It has been reported that some of the sugarbeet varieties require 30-50% less water than sugarcane. Sugarbeet is 5-6 months crop with an average yield of 85-125 t ha⁻¹ and sugar content of 14-20%. Sugarbeet is a biennial plant completing its life cycle in two years. In its first year of growth, it develops a rosette of leaves and a large fleshy root, which stores the food reserve in the form of sugar. If it is left to grow in the second year, it produces flowers and seed. With the help of Syngenta Bangladesh Ltd. and Sessvanderhave Sugarbeet Pilot Project of BSRI has undertaken several studies at BSRI farm, different sugar mills experimental farms and saline areas of the country during last several years. The major objective of the aforesaid studies was to understand the varietal suitability in respect to sowing times, locations and yield.

MATERIALS AND METHODS

The experiments were set in different locations of the country especially where sugarcane is cultivated for sugar production. Two varieties of sugarbeet (Shubhra and Cauvery) supplied by Syngenta Bangladesh Ltd. (Anonymous, 2005.) were used in the experiment. The experiment was laid out in randomized completely block design using unit plot size 6.0m × 8.0m with four replications. In case of intercropping in single row one line sugarbeet was sown in between two rows of sugarcane (100 cm apart) and in paired row system, three rows of sugarbeet were sown in 50 cm line to line distance between two paired rows of sugarcane. Plant to plant distance of sugarbeet was maintained 20 cm for all experiments.

Land preparation: Sugarbeet being a deep-rooted crop requires a good tilth of soil free from clods for its proper growth. After selection of the land, a deep ploughing was done followed by 3-4 light ploughing in every experimental location. Then the land was harrowed and light ridges were made for seed sowing.

Fertilizers application: Sugarbeet responds well to fertilizer and manure. Adequate top and root growth requires large amount of Nitrogen (Ustinenko-Barumovsky G.V. 1983). In the present experiments, MOC, Urea, TSP, MOP, Gypsum, Zinc sulphate and Boric acid were applied at the rate of 450 kg, 250 kg, 120 kg, 225 kg, 100 kg, 10 kg and 20 kg per hectare respectively (Anonymous, 2005). Total MOC was applied at the time of final land preparation. TSP, MOP, Gypsum, Zinc sulphate, Boric acid and 1/3 urea was applied in the line before ridge preparation. Rest amount of urea was applied in two instalments at 30 and 60 days after sowing. In the study where sugarcane was intercropped by sugarbeet additional fertilizers were applied for sugarbeet and it was calculated considering sugarbeet population with full dose fertilizers recommended for sugarcane.

Seed sowing: Polished sugarbeet seeds were sown on light ridge soil at 3-4 cm depth. The distance between two ridges was 50 cm and seed to seed distance was 20 cm. The

varieties used in this trial are monogerm in nature; two seeds per hill were sown to ensure optimum plant population (Figure.1).



Figure.1: Sugarbeet seed sowing

Intercultural operation: After 2/3 weeks of germination, through singling only one plant was maintained per hill. Plant spacing was 50 cm line to line and 20 cm plant to plant which ensures 1,00,000 plants population per hectare. This spacing is recommended by Syngenta for their tropical sugarbeet varieties to achieve higher yield as well as optimum beet size for higher sugar content. Mulching, weeding and other intercultural operation were done as recommended.

Irrigation: Moisture level plays a vital role in root development and crop growth in sugarbeet. It is reported that depending on the soil types and rainfall, sugarbeet crop requires 8-10 irrigations (Motiwale *et al.* 1991). In the present study six irrigations were applied during the growing season.

Pest management: Insect pests and diseases were controlled through mechanical and chemical procedure as and when necessary.

Sugarbeet processing and goor (jaggery) production: Sugarbeet processing is the production of sugar (sucrose) from sugarbeet. Byproducts of sugarbeet processing include pulp and molasses. Sugarbeet processing operations comprise several steps, including slicing, diffusion, juice purification, evaporation, crystallization and sugar recovery from molasses. Prior to removal of the sucrose from the beet by diffusion, the cleaned and washed beets are sliced into long, thin strips, called cossettes. The cossettes are conveyed to continuous diffusers, in which hot water is used to extract sucrose from the cossettes (Singh, *et al.* 1985). Although existing Sugar Mills in Bangladesh are capable to produce white sugar from sugarbeet juice but they don't have required machineries for beet juice extraction. So, we had to try to make some quantity of goor (jaggery) manually using machineries that we have. After washing the harvested beets, slices were done by mini slice machine for cossettes preparation and the cossettes were diffused in a locally made diffuser where temperature of water was maintained 70-72°C. Ratio of water and cossettes was 1:2. Nearly 1.0-1.5 hour's diffused juice was collected and passed through a cheese cloth screens to remove any small cossette particles. The collected juice was used for goor (molasses) preparation by open pan

boiling method without adding any chemical clarificant except liming which was done after 30 minutes of boiling. The physical and chemical properties of goor were studied immediately after the preparation.

RESULTS AND DISCUSSION

The results of the present study are described under the following heads and sub-heads.

Performance of Sugarbeet Varieties Sown in Different Times and Locations

Under this experiment, several yield contributing parameters were recorded which are described below:

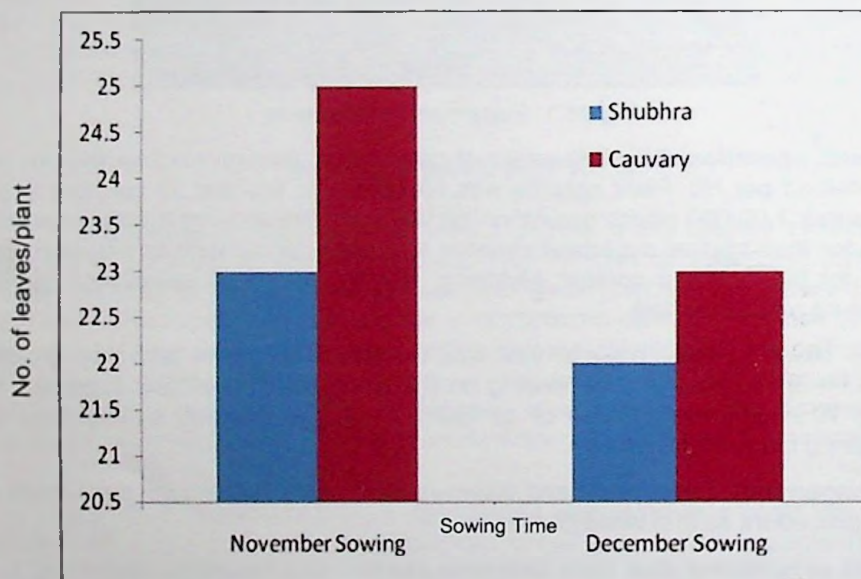


Figure 2: Number of leaves in different sowing times and varieties

Number of leaves per plant: Statistically, number of leaves varied due to varieties and sowing dates (Figure 2). However, Cauvary produced more leaves than Shubhra. On the other hand, leaf number/plant was higher in November sowing than December. Again beet yield was found higher with variety produced more leaves (Table 1). In case of sugar producing in plants, leaves play an important role. In first year of life cycle, sugarbeet plants produced about 3000-5000 cm² leaf area. More productive leaves of sugarbeet are 10th-25th leaf. These leaves grew faster and remained up to 60-70 days. Similar observations were made by Vavilov *et al.*, 1979. At the time of harvest about 40-60% leaves remained alive.

Beet size: The weight of sugarbeet is directly related to beet size and age of plant. Figure 3 reveals that beet weight of Cauvery was higher than Shubhra. It was noted that up to 130 days of sowing beet weight rose then started declining.

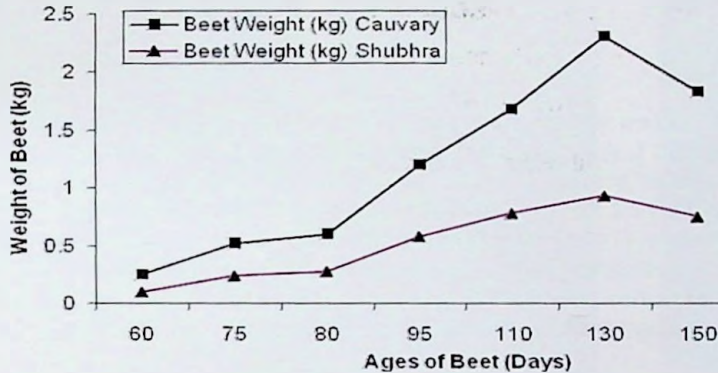


Figure 3: Variation of beet weight in different ages of sugarbeet.

Beet weight with leaves: The weight of beet with leaves was varied significantly between the varieties for early sowing (November) but it was similar in late sowing (December). The average weight was 1.78 kg in Cauvery and 1.32 kg in Shubhra at early sowing. On the other hand, weight was 1.01 kg in Cauvery and 0.97 kg in Shubhra were found at late sowing (December) (Table 1).

Table 1. Performance of sugarbeet varieties sown in different times.

Sowing Date	Variety	Beet weight with leaves (Kg)	Beet Length (cm)	Beet Diameter (cm)	Beet Yield ($t\ ha^{-1}$)	Pol% Beet
November, 2011	Shubhra	1.32b	34.53a	35.00a	75.77b	12.66a
	Cauvery	1.78a	35.12a	36.47a	82.33a	11.26b
December, 2011	Shubhra	0.89c	27.01b	27.80b	71.67c	13.22a
	Cauvery	1.01c	26.37b	25.50b	74.33bc	11.24b
LSD (5%)		0.089	2.008	2.553	3.443	1.371

Beet length: Beet length was significantly varied in different sowing times even within different varieties of sugarbeet. The beet length was higher in November sowing for both Shubhra (34.53 cm) and Cauvery (35.12 cm) varieties of sugarbeet than December sowing (Table 1). But there was no significant difference between the varieties of sugarbeet sown in the same time.

Beet diameter

Beet diameter was significantly varied in different sowing times even within different varieties of sugarbeet. The beet diameter was higher in November sowing for both Shubhra (35.00 cm) and Cauvery (36.47 cm) varieties of sugarbeet than December sowing (Table 1). But there was no significant difference between the varieties of sugarbeet sown in the same time.

Beet yield

At BSRI farm, seeds of two varieties viz. Shubhra and Cauvery were sown on 17 November and 5 December, 2011. Average beet yield (79.05 t ha^{-1}) was found higher in November sowing than December sowing (73.00 t ha^{-1}). The yield was higher in Cauvery (82.33 t ha^{-1}) than Shubhra (75.77 t ha^{-1}) in November sowing and in December sowing the yield was higher in Cauvery (74.33 t ha^{-1}) than Shubhra (71.67 t ha^{-1}) (Table 1). Variety Cauvery produced significantly higher beet yield (82.33 t ha^{-1}) in November sowing compared to variety Shubhra (75.77 t ha^{-1}) but both the varieties gave statistically identical yield in December sowing which were 74.33 and 71.67 t ha^{-1} , respectively.

Pol % beet

The pol % of beet was significantly varied in different sowing times even within the varieties of sugarbeet. The variety Shubhra contained significantly higher sugar than Cauvery in both the sowing times. In November sowing it was 12.66% and 11.26% and in December sowing 13.22% and 11.22%, respectively in Shubhra and Cauvery.

Sowing date is considered the most important factor for all field crops, specially for sugarbeet. In the present experiment, all studied parameters were influenced by sowing time. Again, individual beet variety also responded differently. In the study, November sowing crop gave more biomass compared to December sowing. Number of leaves, individual beet weight, beet length, beet diameter, beet yield and sugar content in beet (pol % beet) were significantly influenced by sowing time. These parameters were found different in different varieties. Early sown plants gave more value than that of late sowing. Same results were also reported by different scientists (Abd EL-Gawad *et al.* 2000; Kandil, *et al.* 2002).

Pest and disease management

At early stage of sugarbeet growth, infestation with cut worm was seen in the experimental fields and was managed manually. In the advanced growth stage of the plant pumpkin beetle and aphid infestation occurred in some places. With the rise of temperature at the end of winter tobacco caterpillar, litura infestation was occurred seriously. For controlling the insects, Darsban, Ripcord, Nitro 505EC were sprayed at 7-10 days interval. For controlling litura caterpillar sex pheromone was also used and worked satisfactory.

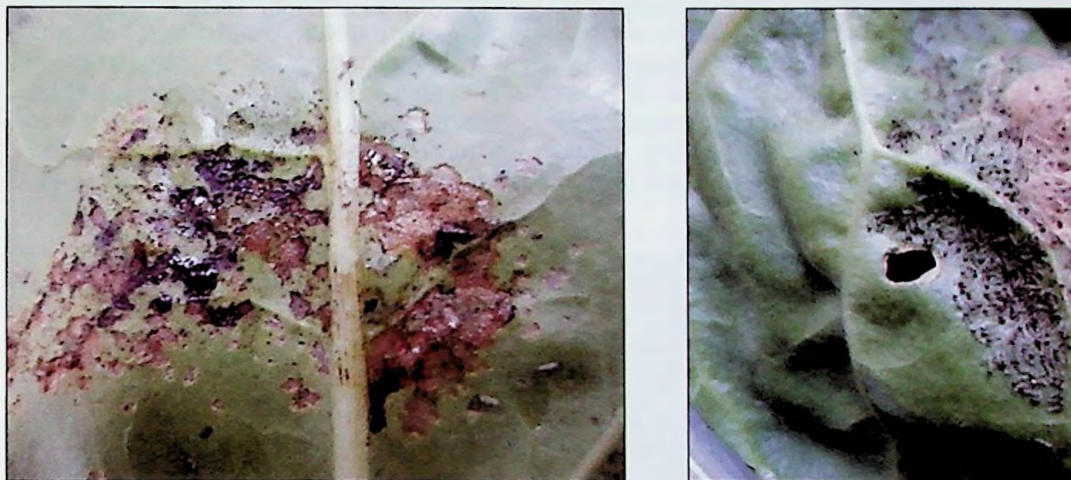


Fig. 4: Insect Infested Sugarbeet leaves



Fig. 5: Diseases infected Sugarbeet plants

At different growth stages of sugarbeet about 8 diseases were identified at BSRI farm as well as in different experimental locations. The diseases were Sclerotium root rot (*Sclerotium rolfsii*), Rhizoctonia root and crown rot (*Rhizoctonia solani*), Cercospora leaf spot (*Cercospora beticola*), Alternaria leaf spot (*Alternaria alternata*, *Alternaria brassicae*), Root knot nematode (*Meloidogyne* spp.), Heart rot/Boron deficiency, Anthracnose (*Colletroticum dematium*) and Crown gall (*Agrobacterium tumefaciens*). For controlling these diseases some fungicides such as Tilt 250 EC, Bavistin 50 WP, Score 250 EC etc. were used and their performance was found satisfactory.

Performance of Sugarbeet as intercrop with sugarcane

Sugarcane is a long duration crop which require about 12-14 months. For that reason, Sugarcane growing lands are replacing by many short duration and high value winter crops. For enhancing sugarcane cultivation intercropping with sugarcane is very essential. Sugarbeet can be grown as intercrop with sugarcane. Table 2 reveals that beet variety Shubhra and Cauvery are suitable for intercropping with single and paired row sugarcane. In both planting systems Cauvery performed better than Shubhra as intercrop with sugarcane. Sugar percent was almost similar in both planting systems and varieties of sugarbeet.



Figure 6. Sugarbeet as intercrop with sugarcane in Paired Row System

Table 2. Performance of sugarbeet as intercrop with sugarcane.

Sugarcane planting Systems	Beet Yield (t ha ⁻¹)		Pol % beet	
	Shubhra	Cauvery	Shubhra	Cauvery
Single row system	50	60	11.48	12.88
Paired Row System	54	57	12.94	12.19

Performance of sugarbeet varieties in different locations of Bangladesh

The results of experiment setup in 12 sugar mills during 2011-12 cropping season presented in the Table 2 showed that beet variety Shubhra produced average 78.0 t ha⁻¹ and Cauvery produced 94.0 t ha⁻¹ of beet. The highest yield (106.21 t ha⁻¹) of the variety Shubhra was found at Thakurgaon sugar mills Ltd. and lowest (51.87 t ha⁻¹) was found at Natore sugar mills Ltd. On the other hand, the highest yield of the variety Cauvery was found 135.85 t ha⁻¹ at Syampur sugar mills Ltd. and lowest (54.34 t ha⁻¹) was found at Natore sugar mills Ltd. Average sugar content was more or less similar in both of the varieties (Table 3). It is important to note that the sugar content in beet was ranged between 10.57% to 15.75%. In saline area, Bagerhat where salinity level was 4-6 dS/m, yield of sugarbeet were 67.0 t ha⁻¹ and 77.0 t ha⁻¹ in Shubhra and Cauvery respectively. Mean pol % beet in that location was 13.08%. On the other hand, in

Satkhira where salinity level was higher (10-14 dS/m), beet yield were 100.0 t ha⁻¹ and 120.0 t ha⁻¹ in Shubhra and Cauvery respectively but sugar content in beet (pol % beet) was found comparatively lower (10.63%) than other places (Table 3).

Table 3. Performance of sugarbeet in different locations.

Location	Beet Yield (t ha ⁻¹)		Pol % beet
	Shubhra	Cauvery	
Thakurgaon Sugar mills Ltd.	106.0	121.03	13.49
Setabgonj Sugar mills Ltd.	79.04	98.8	13.62
Syampur Sugar mills Ltd.	121.03	135.85	13.18
Rangpur Sugar mills Ltd.	61.75	80.28	10.57
Joypurhat Sugar mills Ltd.	88.92	98.8	12.14
Zill Bangla Sugar mills Ltd.	69.16	71.63	13.24
Rajshahi Sugar mills Ltd.	83.98	93.86	13.56
Natore Sugar mills Ltd.	51.87	54.34	15.75
North Bengal Sugar mills Ltd.	66.69	121.03	15.75
Kushtia Sugar mills Ltd.	88.92	98.8	13.21
Cerow & Co. Ltd.	74.10	79.04	12.74
Faridpur Sugar mills Ltd.	69.16	76.57	14.61
Bagerhat (Salinity 4-6 ds/m)	67.0	77.0	13.08
Satkhira (Salinity 10-14 ds/m)	100.0	120.0	10.63
Average	78.00	94.00	13.82

Performance of sugarbeet varieties for goor (Jaggary) preparation

In our laboratory, we prepared two types of goor; semi solid and granular goor. In Table 4, brix % of both the varieties were found identical but goor recovery was higher in Shubhra compared to Cauvery.

Table 4. Performance of sugarbeet varieties for goor production.

Sl. No.	Variety	Beet Yield (t ha ⁻¹)	Brix (%)	Goor Recovery (%)	Goor Yield (t ha ⁻¹)
1.	Shubhra	72.44	20.00	10.37	7.51
2.	Cauvery	75.11	20.17	9.23	6.89
	Mean	73.78	20.09	9.80	7.20

Goor yield also was found higher in Shubhra (7.51 t ha⁻¹). Although variety Cauvery gave higher beet yield but it produced lower quantity of goor (6.89 t ha⁻¹) due to its low recovery.

Physiological properties of goor (molasses) made from Sugarbeet

Physical properties like texture, crystallizing nature, colour in solid state etc. and chemical properties like sucrose content (%), reducing sugar (%), colour, pH, moisture

etc. play a vital role to evaluate goor (jaggery) for their quality and market price. Data furnished in Table 5 indicated that granular goor had more hardness, good crystallizing nature and brown color which are better than semi solid goor.

Table 5. Physiological properties of goor (molasses) made from Sugarbeet.

Sl. No.	Goor sample	Texture	Crystallizing Nature	Colour in Solid State	Remarks
1.	Semi Solid	Soft	Medium	Dark Brown	
2.	Granular	Hard	Good	Brown	

Chemical properties of goor (molasses) made from Sugarbeet

Chemical properties like sucrose, reducing sugar, colour and moisture were also found better in granular goor compared to semi-solid goor (Table 6). Identical pH value (9.25) was found in both the goor sample.

Table 6. Chemical properties of goor (molasses) made from Sugarbeet

Sl. No.	Goor sample	Sucrose (%)	Reducing Sugar (%)	Colour	pH	Moisture (%)	Remarks
1.	Semi Solid	77.00	1.05	25	9.25	7.56	
2.	Granular	81.00	0.91	40	9.25	5.29	



Sugarbeet Field at BSRI



Harvested Sugarbeet



Cossettes Prepared by Slicer



Locally made Diffuser



Open boiling of beet juice



Sugarbeet granular goor

Fig. 6. Processing Goor (jaggery) from Sugarbeet at BSRI

CONCLUSION

Sugarbeet is a new crop in Bangladesh. Selection of suitable genotypes and development of agronomic management practices are very important for its commercial cultivation as an economic crop. The limited studies undertaken by the Pilot Project for development of Sugarbeet Cultivation Technologies in Bangladesh, BSRI is a pioneer in stepping to expand the crop in the country. Results of the study revealed that sugar beet might be cultivated successfully in Bangladesh. As sugarbeet is a salt tolerant crops, its cultivation could be expanded in southern delta of the country not only for crop production but also for salinity reduction of saline soils. Therefore some important decisions should be made by the policy-making authority of the country for its sustainable production.

These are:

- a) Screening sugarbeet varieties suitable for commercial cultivation in Bangladesh and development of its production packages with pest and disease management;
- b) Development of facilities to produce white sugar in existing sugar mills adding of washing unit, slicer, diffuser etc.;
- c) Development of goor production facilities at farmers' level providing mini slicer and diffuser with open boiling chulla;
- d) Development of technologies for economic uses of sugarbeet by-product like pulp, leaves, molasses etc.;
- e) As sugarbeet is a new industrial crop in the country, so a special marketing system should be developed for systematic beet purchasing directly from growers and
- f) An economic support like subsidy on seed, fertilizers, irrigation etc. should be provided to the beet growers to popularize its cultivation.

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