

Sisal

Its scope as a multi-dimensional fibre crop for India

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SISAL is a semi-perennial, leaf-fibre producing plant. Different species of *Agave* (Asparagaceae family) namely *A. sisalana*, *A. cantala*, *A. vera-cruz*, *A. amaniensis*, *A. angustifolia* and *A. fourcroyodes* can produce hard fibre from its leaf. However, among the different species, *A. sisalana* contributes nearly 85% of the total sisal fibre production of the world (381.43×10^3 t). *A. sisalana* is a native of the Yucatan area of Mexico where the fibre had been used by the native Mexican people for centuries. Later, around 1836, sisal was introduced to Florida. Other than Mexico, wide cultivation of sisal was started in Tanzania, where it was introduced by Dr. Richard Hindorf, an Agronomist from Germany. In the present world, major sisal producing countries are Brazil, Kenya, Tanzania, Madagascar, China, Mexico and Haiti (Table 1). In the modern world, sisal/agave was extensively studied by Howard Scott Gentry (1903-1993), who was an American botanist recognized as the world's leading authority on the agaves. Sisal fibre is very commonly used in the shipping industry for mooring small craft, lashing, and handling cargo. Besides, it has several other domestic to industrial uses including high strength requiring long-lasting geo-

textile and speciality composites. In the present world, the main sisal producer and exporter is Brazil and main importer is China. Indian sisal fibre production is negligible, so it imports virtually the whole requirement. Not being a traditional food crop, research on sisal is not very exhaustive not only in India but globally also. Even then, some useful research and transfer-of-technology on planting geometry, nursery management, macro and micro nutrient management, micro-irrigation techniques, weed and disease management, agro-techniques for intercropping with annual legumes, cheap, portable and energy efficient sisal decorticator have taken place in the country. There is no single standard for quality classification of sisal fibre in the world. Different sisal fibre producing countries/region/association follow their own method of grading/classification primarily based on length of the fibre, tenacity, colour/lustre etc. India follows BIS standard for sisal (commercially known as 'Aloe' fibre) for grading and marking. For expanding sisal area and increasing production in the country, initiatives taken by ICAR, State Governments, Non-Government Organizations and private entrepreneurs have been categorically

mentioned. This article describes the strengths, weakness, opportunity and threat associated with sisal for India; and thereby conclude that sisal has a bright prospect in India for several virtues especially cherished in the changing climatic as well as socio-economic condition.

Status of Sisal

World

The total area of sisal growing in the world is 428.1 thousand ha and the total fibre production is 220.2 thousand tonnes. Brazil occupies the lion's share both in terms of area and production (Table 1). Although the sisal area in China is not very significant, but the productivity of sisal in China is the highest (4706 kg/ha) which is about 9 times of the world's average productivity. Sisal area for the last two decades is increasing with moderate positive trend.

Status in India

Several species of sisal are indigenous to India and are growing freely in wild state. It was primarily used by the tribes/villagers to provide fence/hedges but are not often cultivated in the true sense. Although the tribes/villagers use the leaf for extraction of fibre through laborious

Sisal is a xerophytic, monocarp, semi-perennial leaf fibre producing plant. The plant has short stem, bears rosette of leaves that are sessile, linear lanceolate attains a length of 1-1.5 m or more. The leaves are thick, fleshy and often covered with waxy layer; typical characteristics of xerophytic plants. A healthy sisal plant produces about 200-250 leaves during its 10-12 years life span, after which it produces a long flowering axis called 'pole'.

Table 1. Area of sisal in the world

Country	Area (10 ³ ha)	% share of the world
Brazil	248.683	58.09
Tanzania	58.051	13.56
Kenya	40.031	9.35
Mexico	27.282	6.37
Madagascar	15.800	3.69
Haiti	15.107	3.53
Others (Morocco, China, Venezuela, Mozambique, Guinea, South Africa, Cuba, Central African Republic, Ethiopia etc)	23.150	5.41
World	428.104	100.00

<http://faostat.fao.org>

Table 2. Production and productivity of sisal in the world

Country	Production (10 ³ t)	% share of the world	Yield (kg/ha)
Brazil	89.128	40.47	358
Kenya	27.866	12.65	696
Tanzania	25.693	11.67	442
Mexico	20.113	9.13	737
Madagascar	18.937	8.60	1198
China (mainland)	16.000	7.26	4706
Haiti	9.229	4.19	611
Venezuela	6.500	2.95	2000
Others (Morocco, South Africa, Mozambique, Ethiopia, Angola, Jamaica etc)	6.742	3.08	-
World	220.208	100.00	514

<http://faostat.fao.org>

and crude method as the fibres are used for ropes/mats etc. Before invention of sisal extractor, the manual leaf fibre extraction process from sisal leaves was so laborious that Indian jail authorities (Motihari and other places) gave sisal leaves to the inmates of the jail for fibre extraction merely to keep the prisoners employed on sufficient laborious and punitive work. With the development of sisal fibre extraction machines in British East Africa and other parts of the world, sisal fibre became a regular industry. After few years of such machine development in East Africa, in India Mr. J.M. Casey started sisal plantation as the main pioneer of sisal enterprise in the country. Mr. Casey had some more sisal plantations in Odisha and adjoining areas and most of them were in profitable production tune. In 1964, Mr. and Mrs. Casey sold two of their important sisal farms at Nildungri (751 acres or 304 ha) and Beldungri (730 acres or 295 ha) of Sambalpur district to the State Govt. of Odisha. The Govt. of Odisha owned 'Govindapur Sisal Farm' at Bamra having an area of

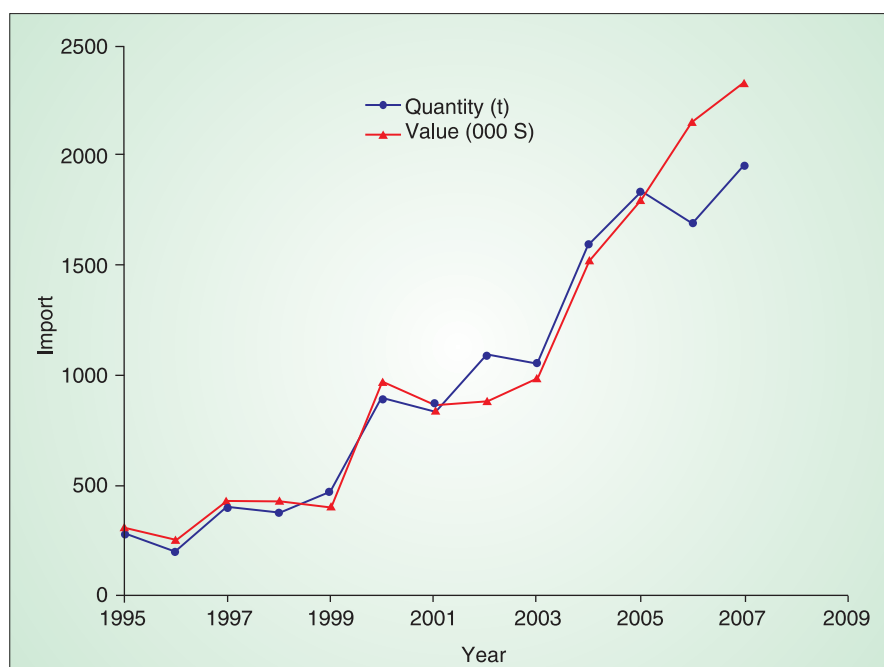
266.13 acres which was handed over to Indian Central Jute Committee (ICJC) through an agreement signed on 17th June, 1962 and subsequently the same had been given to Indian Council of Agricultural Research (ICAR). In the said sisal farm of

Bamra, the sole research station on sisal, i.e. Sisal Research Station is operational as a regional research station of Central Research Institute for Jute and Allied Fibres (CRIJAF). In India, sisal is generally not grown by organized sectors, whereas, it is scattered over isolated areas predominantly as live fence or grown by the tribals for their own consumption of natural fibres. The main fibre producing sisal is *A. sisalana* and *A. cantala*, but in some places, other species of agave (*A. vera-cruz*) give more fibre. In Mysore area of Karnataka, *A. americana* performed better than other species of sisal. The area and production statistics of sisal for India is not directly available from any published and authentic source. However, based on information on demand of planting materials, availability of sisal fibre, interactions with different sisal producing agencies (Govt., NGO and Private entrepreneur) it may be estimated that the sisal area in India will be between 1800 and 2400 ha with a production of 1080-1440 tonnes.

Trade Information

Import

China is the largest sisal fibre importing country, followed by Spain and Mexico (Table 3). Although the



Import of sisal by India from 1995 to 2007

Table 3. Import and export of sisal fibre in the world

Country	Import (10 ³ t)	Country	Export (10 ³ t)
China	43.2	Brazil	52.6
Spain	7.8	Kenya	22.1
Mexico	7.1	Madagascar	12.9
Morocco	3.7	Tanzania	10.1
Portugal	3.4	Belgium	2.1
Others (Saudi Arabia, Belgium, Kenya, India etc)	30.7	Others (Netherlands, USA etc)	3.2
World	95.9	World	103.0*

*includes FAO data and estimated data using trading partners database <http://faostat.fao.org>

sisal fibre production in India is not very high as compared to her domestic need, but sisal fibre is an important commodity permitted to export to Pakistan from India (H. S. No. 5304.000 and 5304.000, *i.e.* sisal fibre including waste of sisal) as per the India-Pakistan Trade Order dated 3rd November 2006.

Import by India

In 1995, India imported 284 t of sisal fibre by spending \$ 30,400 which increased to 1951 t in 2007. Analysis of Indian import figure of sisal fibre showed that the demand increased at least 7 times within 12 years period and the same will rise to 23,000 tonnes in the middle of the current century at the present rate of population and industrial growth. Projection of import value will go as high as 44 million US Dollar in 2050.

Export

Brazil and Kenya are the main sisal fibre exporting countries of the world (Table 3).

Fibre Composition, Quality and Grading

Sisal fibre varies widely in quality. The variation in chemical composition is because of its different sources, age, extraction methods etc. It was indicated that sisal fibre contains 78% cellulose, 10% hemicellulose, 8% lignin, 2% waxes and about 1% ash by weight. But others found that sisal contains 43-56% cellulose, 7-9% lignin, 21-24% pentosan and 0.6-1.1% ash. It was also reported that the cellulose and lignin contents of sisal vary from 49.62-60.95% and 3.75-4.40%, respectively, depending on the age of the plant. From India, it was

mentioned that the sisal fibre is composed of cellulose (78%), hemicellulose (10%), lignin (8-10%), wax (2%) and 1% ash. In general, the physical properties of sisal are, 0.6-1.2 m length, 0.05-0.2 mm diameter, 1.35 g/cm³ density; the mechanical properties are tensile strength 500-660 MPa, tensile module 30-40 GPa and 2-3% elongation.

There is no universal standard of grading sisal fibre in different countries in which it is produced. Different countries have their own system of fibre grading. Brazil, the major producer of sisal classify fibre based on fibre length; the classification is Extra-long (>110 cm), Long (90-110 cm), Medium (70-90 cm) and Short (60-70 cm). In India, the BIS authority follow 'Aloe Fibre Grading and Marking Rules, 1975' as in the country fibre obtained from the botanical species of *Agave cantala*, *A. sisalana* and *A. Vera-cruz* are commercially called 'Aloe' fibre. The grade designation and definition

of quality of sisal fibre are given in Table 4.

Indian Initiative for Development of Sisal

Initiatives by ICAR

Since 1962, Sisal Research Station of CRIJAF have been involved in development of economically viable and sustainable production technology for sisal, collection, maintenance and improvement of sisal types for higher yield and better fibre quality, transfer of technology and human resource development in relation to sisal. Number of sisal related technologies like nursery management, double row planting geometry, weed management, macro and micro nutrient management, water saving and efficient irrigation technique, concept and agro-technique of annual legume intercropping in sisal, management of zebra disease and development and commercialization of cheap, portable and energy efficient sisal decorticator have been developed and put to use for the sisal planters of the country.

From 2011-12 financial year onwards, under Tribal Sub Plan (TSP), ICAR has earmarked considerable amount in each year for expansion of sisal area and dissemination of improved production technology through its establishment at Sisal Research Station (of CRIJAF) located at Sambalpur district of western Odisha. In 2011-12, about 12 ha of

Table 4. Grade designations and definition of quality of Aloe/ Sisal fibre in India

Grade Designation	Maximum limits of tolerance		Special characteristics		General characteristics
	Foreign matter (% by weight)	Harsh fibre (% by weight)	Colour	Minimum length (cm)	
Special	3	5	Creamy white	80	(a) The fibre shall be reasonably soft texture and uniform colour. It shall be clean and reasonably dry. (b) The strands shall be reasonably uniform in length and strength and free from tangling, knot spines and other undesirable materials
No. 1	5	10	Pale creamy white	70	
No. 2	8	25	Greyish or brownish white	60	

Definition of Terms: 'Foreign matter' includes dust, lumps of earth, sticks, tangled mass of very short and weak pieces of strand and skin waste and any other impurity; 'Harsh Fibre' means fibre which has become very hard or harsh due to improper extraction.

new sisal plantation was started by the tribal farmers following improved package of practices in the tribal dominated Sambalpur and Jharsuguda districts of Odisha. In the subsequent years, another 20.36 ha area (2012-13) and 17.11 ha (2013-14) were brought under new sisal plantation in Odisha by the tribal farmers under the programme. At the same time about 1.32 lakh healthy sisal suckers were produced and distributed among the sisal planters for further expansion of sisal area in another 33 ha. Sisal area expansion programmes are continuing with financial support from TSP. Similar pursuit of sisal popularization and area expansion in Ranchi area of Jharkhand has been initiated with active involvement of Sisal Research Station (of CRIJAF) and Divyayan Krishi Vigyan Kendra of Ramakrishna Mission Ashram, Ranchi. Newer production technologies, such as double row planting system, use of balanced fertilizer, legume intercropping with sisal etc. were successfully transferred to the farmers field under the TOT programmes of the research station. Several HRD programmes such as trainings, awareness camps, farmers' meetings were conducted by the institute which created interest about the crop among the farming community of Odisha, Jharkhand, Madhya Pradesh and Andhra Pradesh. In the current financial year (2014-15), a more focussed and mammoth scale project titled 'Enhancing indigenous availability of sisal fibre for industrial use' has been approved in principle with a budget outlay of ₹ 389 lakh initially for three years ending March, 2017 under Natural Fibre Platform Projects. The outcome of the project surely have greater role for increasing indigenous availability of sisal fibre in the country resulting in reduced dependency on import and thereby making sisal as one of the important natural fibres of India.

Initiatives by Government of Odisha

In Odisha, the state department of soil conservation have several sisal plantations at Nildungri, Beldungri, Bargaon, Itma, Sundargarh,

Rajgangpur and other places for the purpose of soil conservation. Till date, the farms are owned and managed by the Soil Conservation Department of Govt. of Odisha. But it is quite surprising that the Beldungri (730 acres) sisal farm was abandoned in 2002 by the state Govt. due to financial crunch and/or other inevitable reasons. The other farms are maintained by the department primarily for soil conservation purpose and not for economic output of fibre (www.obac.in; Odisha Budget and Accountability Centre). However, there is a distinct possibility of harvesting of leaves and production of fibres without compromising with the ability of the sisal plantation for soil conservation. Even very conservative estimate of production potential from all those plantations of soil conservation department of Odisha, about 260 to 360 t of sisal fibre can be obtained each year. Considering the employment and income generation potential, the District Rural Development Agency (DRDA), Koraput, Odisha implemented an "Integrated Sisal Plantation, Fibre Extraction and Rope Making" programme under Jawahar Rojgar Yojana in 1995.

Initiatives by Government of West Bengal

The dry and lateritic region of western (Birbhum, Bankura, Purulia) and south western part (west Midnapur) of West Bengal have ideal condition for growing sisal on commercial scale. State government owned Rajnagar Sisal Farm with an area of 1100 acres is located at Jharkhand adjoining Rajnagar block of Birbhum district. The state has two more sisal establishments namely Keleghai Sisal Research Station at Sankrail area and Sisal Farm at Abas area in Paschim Medinipur. Both the sisal establishment of Paschim Medinipur are now defunct due to several reasons. Earlier Rajnagar Sisal Farm was actively operational, but at the first decade of the present century (2000), several socio-political and management problems forced the farm towards defunct state. But it is high time to realize by all the

stakeholders that revival of such sisal farms is the need of the hour to develop the comparatively backward socio-economic region of the state in the fast changing social as well as climatic condition.

Initiatives by Non-Government Organizations and Private Entrepreneurs

In British India, sisal was a profitable venture for the private entrepreneurs. Well after independence, there was lack of initiatives as sisal plantations become uneconomic due to several technological as well as socio-economic hurdles. However, in recent years, number of NGOs and private entrepreneurs are showing interest in sisal and started thinking and acting seriously about sisal. As for instance, KoraputSisal BikashParishad grows sisal in Koraput (Sadar), Kakirguma, Nandapur and Muchkund area in Koraput district and their annual production of sisal fibre is about 100 tonne at present and achieving higher production steadily. Some private enthusiastic entrepreneurs at Jaypore area also grow sisal and extract fibre using their own fibre extraction unit. A Self Help Group operating at Kashipur area in Rayagada district of Odisha are also cultivating and producing sisal fibre. NGOs operating at Jabalpur area of Madhya Pradesh and different parts of interior Andhra Pradesh have taken initiatives to popularize scientific sisal cultivation and thereby sisal area is increasing slowly.

Role of Different Institutions and their Interactions for Expansion of Sisal Area and Increase in Production in India

In the Indian context, several component institutions are involved for expansion of sisal area and increasing production in the country. The ICAR-CRIJAF/ Sisal Research Station/ Task Force/ Core Group will be in the key position for technology generation, extension of knowledge through training and demonstration to the TOT trainers from concerned line departments. Directorate of Jute Development may be involved through their several extension (FLD)/ research programmes like

Technology Mission (Mini Missions). In this process of extension and motivation, State Department of Agriculture has a major role to play. KVK of the concerned districts should keep direct linkages between the planters, State Agriculture Department and Sisal Research Station for training, motivation and extension of technical knowledge. Either directly or through Sisal Research Station, KVK also should be involved with the NGOs having target of agricultural and rural development. The State Department of Soil Conservation and Department of Forest may have a closer cooperation regarding expansion of sisal area and also will keep contact with the State Agricultural Universities and Sisal Research Station.

The KVIC, Renewable Energy Department and Organic Manure Programme should also be involved as they will play a key role in the sisal biomass utilization for the benefit of the sisal planters directly. NABARD, other Nationalized Banks and lead banks of the districts will be approached by the Planters' Cooperative/ Sisal Growers' Association or by big individual planters for financing in this endeavour. There is no need to sell

the produced sisal fibre by the individual grower. Whereas, they will sell the fibre through their cooperatives/associations to the fibre buyer or to the industry. Value addition and end product industry may have marketing and also export arrangements of their own.

SWOT ANALYSIS FOR SISAL

Strength

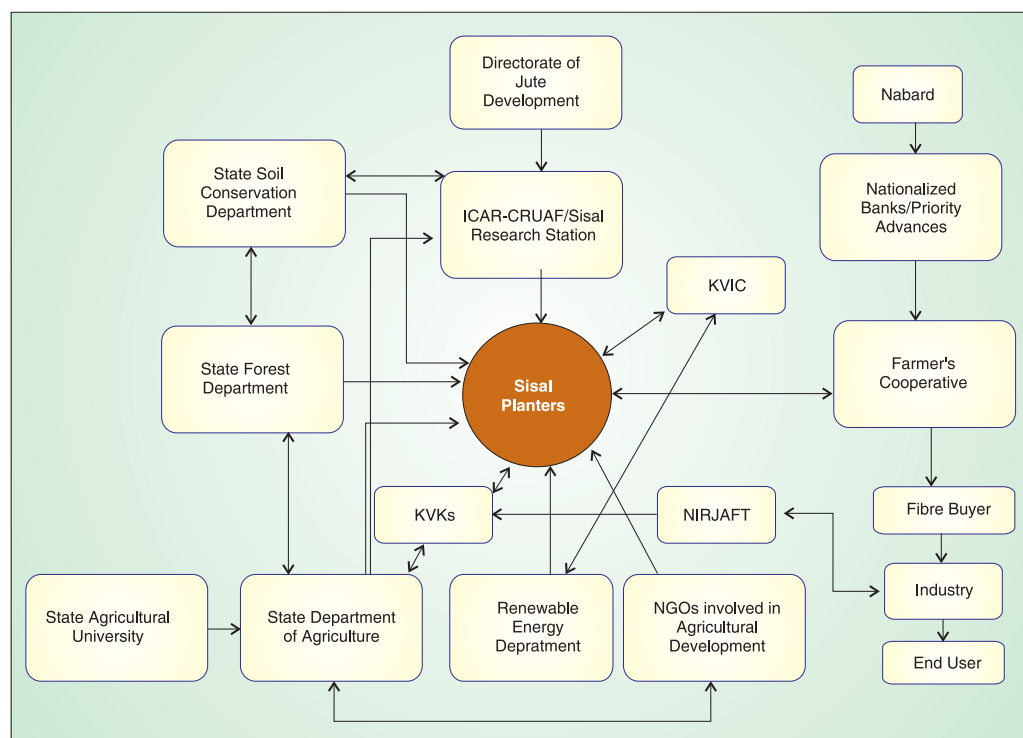
- Agave, in general, is well adapted to arid environment as the species is xerophytic in nature.
- The crop of sisal is well suited under the changing climatic situation characterised by elevated mean temperature, erratic and insufficient rainfall.
- The blue water footprint (surface and ground water consumed) of sisal is only 9 m³/t of sisal fibre produced which is much lower than other vegetable fibre crops such as jute (33 m³/t) and ramie (201 m³/t).
- Moderate waste lands can also be utilized for growing sisal with economic benefits provided adequate crop care is taken by adopting improved package of practices.
- Recommended double row planting of sisal checks soil

erosion, restrict runoff loss of rain water, improves absorption of rain water in the soil layer.

- Being a perennial crop, it requires less agro-activities and thereby minimum soil disturbances occur.
- Fortunately sisal is not heavily infested by many diseases and insect pests beyond certain degree causing economic loss. Therefore, sisal plantation does not add pesticide load to the environment.
- A number of value added uses has been identified and documented.
- Sisal cultivation and fibre production in the poor socio-economic regions of the country may act as elixir for the social malady arising out of sense of neglect or deprivation resulting in separatist/out of the mainstream movements.

Weakness

- Comparatively larger area (say >1 ha) is needed for economically viable plantation of sisal
- Unlike several other fibre crops, extraction process involves mechanical extractor called decorticator which is often beyond the affordability of small and marginal farmers.
- Propagated through vegetative means, so availability of planting materials (bulbils and suckers) for larger area is inadequate. Moreover, it involves transport cost and possibility of physical damage to the living plantlets reduce survival rate.
- Initial longer harvest holiday (for 3 years or so) disinterest common resource-poor farmers/planters.
- Lack of sufficient number of high yielding varieties/ types to choose for specific situations.
- Comparatively narrow genetic base for improvement in fibre productivity and quality.
- Low or negligible credit flow in sisal plantation sector.
- No well-known



Schematic diagram of institutions and their interactions for expansion of sisal area

quality standard, so farmers are forced to sell at lower price offered by the middlemen/ fixed by the mills.

- Unorganized marketing facilities and non-existent extension networks.

Opportunity

- Due to several desirable inherent qualities, sisal has ample scope for product diversification and value addition. The broad classification of such diversified products includes, sisal based geotextiles, coir and sisal blended yarn, biodegradable natural fibre composites, sisal/glass fibre reinforced hybrid composites, sisal fibre reinforced thermostats, sisal fibre reinforced thermoplastics, sisal fibre reinforced rubbers, sisal fibre reinforced cement and gypsum.
- Fortunately, in recent years, appropriate agro-technology to grow annual legumes namely cowpea, pigeon pea, black gram and green gram as intercrops in sisal for initial 3 years has been standardized. Therefore, even the resource poor sisal farmers will get economic return from the piece of land for initial 3 years harvest-holiday phase of sisal. This practice also contribute in minimizing soil erosion due to thick foliage cover, improve soil health by increased rhizospheric soil microbial activity and positive nutrient balance.
- Sisal responds to precision placement of water through drip method. This system of precision irrigation not only saves amount of water but also increases water use efficiency. The same has been proved in number of field experiments in double rowed sisal plantation where limited drip irrigation during the summer months (April-June) increased the sisal fibre yield from 33 to 47%.
- Portable sisal decorticator was designed, developed and tested successfully. The new decorticator provides improved processing of sisal fibre with less energy input and able to provide 55-60% more fibre than the existing one. The

decorticator has already been commercialized through a MOU between the inventing institute (CRIJAF) and the large scale manufacturer operational from Odisha. So the long felt need of cheap, portable and energy efficient sisal decorticator has been fulfilled.

- Sisal waste can be used as good mulching material in other crop to conserve soil moisture in different cropping situation. It can also improve soil conditions and other characteristics of the soil.
- Sisal can save trees as this leaf fibre crop produces huge amount of biomass which can be utilized for paper pulp. Bleached and unbleached sisal pulp is ideally suitable for manufacturing of different quality papers such as dielectric paper, vacuum and tea bag, filtration paper. Bleached sisal pulp can be used for cigarette paper.
- Sisal leaf decortication residue has good potential for bio-methane production ($0.2 \text{ m}^3 \text{ CH}_4/\text{kg}$ residue added) after pre-treatment by lignolytic CCHT 1 and *Trichoderma reesei*.
- Agricultural activity in sisal plantation requires at least 140-160 man-days at the present level of mechanization in agriculture of peninsular India. In a state like Chhattisgarh, Odisha and Madhya Pradesh, sisal plantation can generate rural employment of not less than 4-5 lakh man-days every year.
- Sisal fibre based rural handicraft and small industry further augment the employment opportunities in those states.
- Some national financial institutions (such as NABARD) have programmes through which sisal can be raised in wasteland and also has scheme for assisting rural women entrepreneur dealing with sisal based handicrafts.
- Sisal crop can help to raise the socio-economic status of the tribals where large areas of land are lying unutilized and unproductive. It provides working opportunities in off-season in remote tribal areas of the country.

- Sisal based product diversification (handicrafts, floor covers, carpets and low cost composite building materials) is a distinct possibility.
- Harnessing important secondary metabolites like 'Hecoginine', etc from sisal has bright prospect in India.
- India imports about 2000 tonnes (1964 tonne in 2006) of sisal fibre by paying US \$ 2.33 million. So, domestic production may save valuable foreign exchange.
- In the line of 'London Sisal Association', Indian Sisal Producer and Marketers Association may be formed and activated for getting better opportunity in the global market of natural fibres.

Threat

- Global competition from China and Brazil, producer of quality sisal fibre.
- Steep competition from cheap man-made fibres in general and synthetic based composites in particular.

SUMMARY

Sisal fibre has a bright prospect for its versatile nature encompassing eco-friendliness, suitability for moderate wastelands, apt for changing climatic situation due to low water requirement, high water use efficiency (CAM plant), survival and economic output even in very high ambient temperature; it puts minimum pesticide load to the environment through its cultivation process, being semi-perennial and with lower agro-activity it conserves soil. Sisal is the most viable option for employment opportunity and rural development in the tribal dominated and socio-economically less developed parts of the country; vast arena of sisal based composites with targeted characteristics, sisal based geotextiles have edge over others due to presence of higher strength and impregnated waxy material and a bunch of engineering applications, etc.

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