

Improved production technology of sisal

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Abstract

Agave sisalana Perr., commonly known as Sisal or Agave of Agavaceae family is a xerophytic perennial leaf fibre yielding crop. In India, sisal is mainly found in Orissa, Maharashtra and southern states. Types of sisal available in India are *Agave sisalana*, *Agave cantala*, *Agave vera-cruz*, *Agave amaniensis*, *Agave angustifolia* and *Agave fourcroyodes*. Among these types, *A. sisalana* is the commercial type and used for fibre production. Sisal can survive drought condition but areas having evenly distributed moderate rainfall are suitable. It can be planted on a wide range of soils. However, light calcareous and gravelly soils with good drainage are suitable. Sisal is mainly propagated vegetatively through bulbils and suckers. For sisal planting, pits of 1 ft³ are recommended. Pits are filled up with mixture of soil and organic matter. Two methods of planting viz. single row planting and double row planting are followed. Double row planting is always more profitable. Plant density depends on nature and fertility status of soil, type of farming, investment and management capacity of the grower. Some of the suitable spacing are 4 m + 1 m X 1 m (4000 plants/ha) and 3 m + 1 m X 1 m (5000 plants/ha). Planting are done with the onset of monsoon rain, so plants establish well. During the initial couple of years, harvesting of leaves are not recommended and sufficient space in between rows are available for intercropping of horse gram, finger millet and other small millets, blackgram etc. Hoeing and weeding are essential at least for the first three years. After each weeding, application of fertilizer is recommended @ 60:30:60 kg of N, P₂O₅ and K₂O/ha. Harvesting of leaves is started at 3 years 6 months crop age. At first cutting 16 leaves and in each subsequent cutting 12 leaves are left on the plant. The harvested leaves are then transported to the extraction shed and extraction of fibre is done on the same day or preferably next day as early as possible by deploying raspador decorticador. The fibre is repeatedly washed in water and then spread on ropes or wires till it is sufficiently dry. In general, the average productivity of sisal in India is not more than 600 kg/ha. However, improved techniques with proper management of sisal plantation can produce 1.5 t/ha. A net profit of Rs.20,000 is normally achievable from a hectare of sisal plantation.

Introduction

Different species of *Agave* (Agavaceae family) namely *Agave sisalana*, *Agave cantala*, *Agave vera-cruz*, *Agave amaniensis*, *Agave angustifolia* and *Agave fourcroyodes* can produce hard fibre from its leaf. However, among the different species, *Agave sisalana* (n = c. 69) contributes nearly 85% of the total sisal fibre production of the World. *Agave 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). China is the largest sisal fibre importing country, followed by Spain and Mexico; whereas Brazil and Kenya are the main sisal fibre exporting countries (Table 2).



Field view of sisal plantation in India

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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. Production and area of sisal in the world (2005)

Sl No.	Country	Production (10 ³ t)	Area (10 ³ t)	World production contribution
1	Brazil	213.1	241.6	64.6%
2	Kenya	25.8	26.0	7.8%
3	Tanzania	23.5	46.0	7.1%
4	Madagascar	17.2	14.5	5.2%
5	China	17.0	4.2	5.1%
	Others (<i>Mexico, Haiti, Morocco, South Africa, Mozambique etc</i>)	33.5	52.8	10.2%
	World	330.1	385.1	100%

Table 2. Import and export of sisal fibre in the world (2006)

Sl No.	Country	Import (10 ³ t)	Country	Export (10 ³ t)
1	China	43.2	Brazil	52.6
2	Spain	7.8	Kenya	22.1
3	Mexico	7.1	Madagascar	12.9
4	Morocco	3.7	Tanzania	10.1
5	Portugal	3.4	Belgium	2.1
	Others (<i>Saudi Arabia, Belgium, Kenya, India etc</i>)	30.7	Others (<i>Netherlands, USA etc</i>)	3.2
	World	95.9	World	103.0*

* includes FAO data and estimated data using trading partners database

Climatic requirement

Agave, in general, is well adapted to arid environments as the species is xerophytic in nature. It can withstand a maximum temperature near 50°C and grows well with evenly distributed rainfall of 60-125 cm. Excessive rains (causing water stagnation) and very low temperature causing frost tend to damage the plantation.

Soil

Sisal thrives best on dry, permeable, sandy-loam soils with good amount of liming materials (Ca and Mg) but can also grow on various other types of soils. In India it is grown in light calcareous and gravelly soils with good drainage. Heavy soils having possibility of water logging are not suitable as the condition causes pale and stunted growth of sisal. Adequate calcium in soil promotes development of the root system. It was tested that red earth and coral lime stone gives higher fibre yield of sisal.

Acidic soils with poor calcium content are not suitable for sisal plantation. Moderate waste lands can also be utilized for sisal with economic benefits provided adequate care is taken by fertilizing the crop and adopting suitable agricultural practices including soil ameliorants.

Planting material

Growth of sisal plant is terminated with the emergence of flowering stalk known as 'pole'. Fruits are seldom formed as flower shrivel and fall owing to the formation of an abscission layer at the top of the pedicel and therefore, setting of seeds is not common. Sisal is mainly propagated by vegetative means such as 'bulbils' and 'suckers'. Bulbils develop from tiny buds present on each flower stalk. A bulbil is a plantlet consisting of a meristem, 4-7 reduced leaves and rudimentary adventitious roots. A pole of a sisal plant may produce 400-800 or more bulbils. These bulbils develop and attain a size of 4-5 cm when they are collected during mid February to mid April and raised in nurseries. The underground adventitious shoots that develop from the roots receive favourable condition, often come up at some distance from the parent plant above the soil surface and develop into small plants known as 'suckers'. After few months nurturing, these suckers are also used as planting material for new sisal plantation. Suckers can be collected 3-4 times in a year from a mature plantation. Sometimes, the suckers are left as such with the parent plant to grow for one year or so, which can be used for planting purpose without raising them in the nursery. Use of such suckers as planting material saves the nursery raising cost. However, suckers are not suitable if long distance transportation is involved as it reduces survival rate and adds cost. In such cases, bulbils are preferred as large number of bulbils can safely be transported to a longer distance without considerable loss of viability. Uses of healthy and well developed planting materials are always preferred for planting purpose.



Sisal 'pole' is the source of bulbils



Sisal bulbils

Attempts were made to use other methods such as somatic embryogenesis for sisal propagation. Sisal plantlets regenerated from embryo produced through somatic embryogenesis were transferred to the main field and the survival rate was 95% or more.

Nursery management

The freshly collected bulbils are raised in nurseries with an intention to produce high quality planting materials in shortest possible time. The selected land for nursery should be well drained, fertile (with organic matter), flat as far as practicable and situated near the irrigation source. Pulverized and airy soils accelerate quick initiation of roots and root development occurs rapidly. In sisal two types of nurseries are in practice:

Preparatory or primary nursery

Preparatory nurseries are raised to rear fresh bulbils with intensive care and management during 3-4 summer months. Very small suckers can also be raised in such nursery when sufficient bulbils are not available. The spacing should be closer to accommodate more plants in a small area and are generally spaced 7 x 5 cm in flat raised beds of 1 m width. Planting can be done with the help of marked rope and pegs. Before planting, watering is required to create clear holes for putting bulbils in place. Bed should be weed free as far as possible to reduce unnecessary competition.



Sisal bulbils planted in nursery

Secondary nursery

Bulbils are transferred from preparatory nursery to the main nursery. The roots of the plantlets from the primary nursery are pruned lightly and the diseased & dead leaves are removed. Bulbils are treated with Cu-fungicide before planting them into the main nursery. Planting in main nursery is started with the onset of monsoon and completed as early as possible. A spacing of 50 x 25 cm was found better for rapid development of sisal plantlets. Every 11th row is skipped to get space facilitating weeding and other inter-cultural operation. The recommended spacing of 50 x 25 cm can accommodate 80,000 bulbils/ha of which about 72-76 thousand ultimately survive for planting in the main field. The holes are made with wooden stick along the marker rope in the field and bulbils are planted in these holes upto the neck region. Both shallow and deep dibbling are avoided. In general, N, P and K @30:15:30 kg/ha is applied in addition to organic matters. Organic and inorganic mulches showed encouraging growth of sisal in limited or non irrigating situation. Bulbils are very much sensitive to weed competition at the early growth phase. The nurseries should be kept relatively weed free.

Planting in the main field

Grading of sisal planting materials proved beneficial, but it is not in practice in India due to several factors including shortage of planting materials. The planting materials should not be kept in heaps. It may be kept for 30-45 days on soil under shade in single layer without any adverse effects on growth and fibre yield.

Land preparation

Being a xerophytic and hardy crop, lands available for sisal cultivation are often sloppy, eroded and most of them are without any vegetation cover. So, it is not advisable to plough-open the whole area encouraging further erosion. Pit planting is recommended for such land situation.

Size of pits

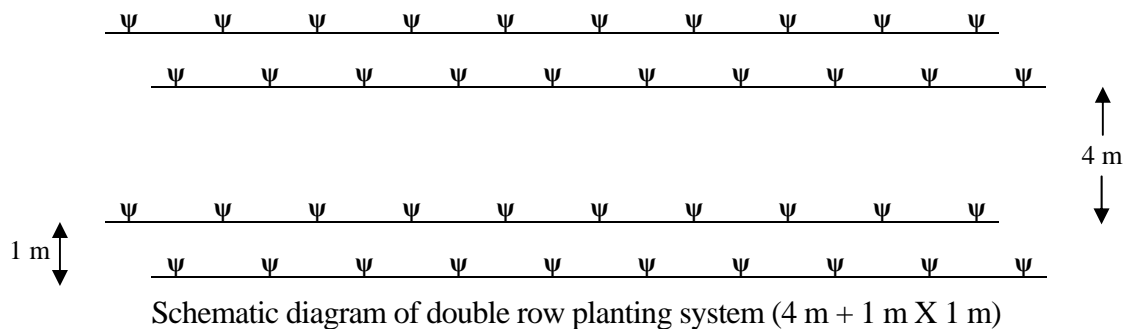
Pit size of 1 ft³ is preferred for getting fast and uniform growth of sisal plants. Pits are dug during summer months and filled up with soil-organic matter mixture. Soil ameliorants may be used in the pits to rectify pH.

Planting method

Two methods of planting are followed. Single row planting method is conventionally practised and is less profitable. Whereas, double row planting method has several merits including checking soil erosion, accommodates more plants/ha and gives higher yield. Rows are made across the soil slopes.

Spacing

Plant density depends on nature and fertility status of soil, type of farming, investment and management capacity of the grower. The following spacings are suitable: 4 m + 1 m × 1 m (4000 plants/ha); 4 m + 1 m × 0.8 m (5000 plants/ha); 3 m + 1 m × 1 m (5000 plants/ha); 3 m + 1 m × 0.8 m (6250 plants/ha); 2 m + 1 m × 1 m (6666 Plants/ha).



Time of Planting

Planting should be taken up with the onset of monsoon, so plants get sufficient time to establish well during the favourable rainy season.

Gap filling

Even after careful planting, non-surviving gaps are common; so, gap filling is necessary in the next rainy season if irrigation facilities are not available.

Mulching

Sisal waste can be used as good mulching material to conserve soil moisture. It can also improve soil conditions and adds nutrients to the soil. Mulching can also be practised by using locally available grasses and other weeds before flower or seed formation.

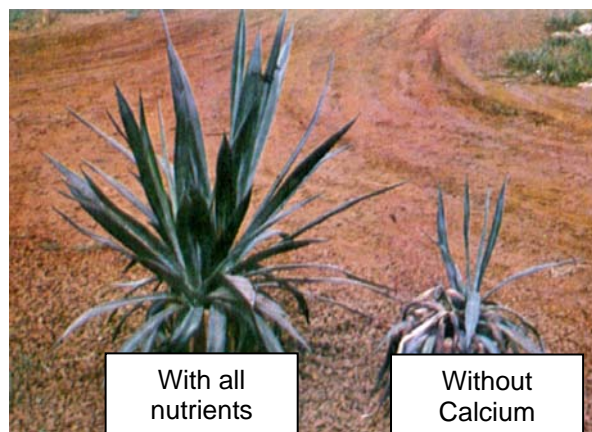
Intercropping

During the initial three years growth period of sisal, harvesting of leaves are not recommended and during this phase inter-row space may be utilized by practising inter-cropping in double row planting system. Crops like horse gram, blackgram, finger millet and other small millets can be intercropped successfully.

Fertilizer application and other intercultural operations

Sisal in general is a nutrient demanding crop as 1 t of sisal leaves removes 23.5 kg N, 3.5 kg P, 35 kg K, 81 kg Ca and 30 kg Mg from the soil [*Soil Use and Management* Vol. 10]. In Tanzania, during mid 60's, annual production of sisal was 234 thousand tonnes, but within 20 years of continuous sisal cultivation without fertilizer application, the production declined to mere 30 thousand tonnes [*Outlook on Agriculture*, Vol. 24]. Therefore, sustainable and

successful cultivation of sisal depends primarily on good management of soil fertility besides other factors. At the tail end of monsoon, hoeing and weeding are done followed by application of fertilizers at least for the first three years of very active growth phase. Application of fertilizers should be done according to the fertility status of the soils and resources at disposal. In general, sisal growing soils are poor in fertility with acidic pH range. N, P and K fertilizers @ 60:30:60 kg/ha/year is recommended for medium fertile normal soil condition.



Calcium plays vital role for nutrition of sisal plants
[Source: *Bragantia*, Vol. 41]

Harvesting

First cutting, in general, starts at 3 ½ years crop age. However, in intensive cultivation programme with appropriate care, first harvest can start at 2 ½ years of age also. At first cutting 16 leaves and in each subsequent cutting 12 leaves are left on the plant. Harvesting during November to February is advised considering several factors like comparatively lower temperature, minimum rain hindrance, restricted active growth and economy in harvesting and extraction operation. After cutting, the leaves are bundled (say 50 numbers) and the bundles are transported to the extraction unit. Extraction of fibre is done on the same day or preferably next day as early as possible.



Harvested and bundled sisal leaves



Carrying of sisal leaf bundles to decortication unit

Fibre extraction

Fibre is extracted from the harvested leaves by using decorticators. Two types of decorticators are used.

Raspador type decorticator redesigned at Central Research Institute for Jute and Allied Fibres (ICAR), Barrackpore, West Bengal are now widely used in India. These are one drummed and single feeder decorticators which are run by 5 HP diesel engines. AC operated motors can also be used in place of diesel engine. Leaves are fed into the machine mouth by one person. A

distinctive feature of this type of raspador is that the leaves enter the machine endwise to make rasping action gradually. On entering, the knives/blades progressively smash and tear off the leaf tissues at closely and regular spaced blades. The fibre portion of the leaf remains in the hand of the operator. The average output of these decorticators is 100 kg wet fibre/day. The said small decorticators are easy in working and cost only Rs12, 000. With some modifications, these decorticators have been converted to two men fed decorticators (double fed). The fibre output is nearly double as compared to the one man fed decorticators.



Extraction of sisal fibre using decorticators

Automatic fibre decorticators consist of two covered drums placed at opposite sides of a central line along which the leaves are conveyed and the fibre is delivered after decortications. In this process the leaves enter cross wise instead of end wise and decortications take place in one full swoop. All the leaf tissues are crushed and scraped off the fibres almost simultaneously because feeding of leaves can be done at much faster rate. Such decorticator can extract 25,000 leaves or 10 tones leaves by weight/hour. These decorticators are not manufactured in India.



Washing of freshly extracted fibre



Drying of washed fibre

Processing of the Fibres

After decortications the fibre is washed in water and then spread in thin layer on ropes or iron wires till it is adequately dry. There after the fibre is beaten with wooden round poles to remove foreign cells/materials which remain attached with fibre during extraction process. Usually the dried fibre shows slight greenness in colour. To make fibre white, next day this greenish fibre is spread under the direct sunlight on the cement or grass floor. The green colour bleached quickly to whiteness in presence of moisture; hence, water is sprinkled over fibre to accelerate the bleaching process. On completion of drying, fibre is collected in small bundles and then baled for transportation and marketing.

Some degree of occupational hazards is involved in sisal fibre processing. Processing of sisal fibres has a high prevalence of acute respiratory symptoms. Brushing workers are more affected than the decortication workers (*Occupational Medicine*, Vol. 57).

Yield

Sisal productivity is highest in China (4 t/ha). The average yield of sisal fibre in India is poor and does not exceed 600 kg/ha. But with proper care and attention and by using improved cultivation techniques, the fibre yield could be achieved to 1.5 t/ha.



Dried sisal fibre

Economics of Sisal Cultivation

Sisal plantation can earn yearly net profit of Rs. 20, 000/ha. As per studies conducted by Sisal Research Station, Orissa, an input out put ratio of 1:5 was obtained on poor undulated waste acidic soils in rainfed areas of the country. Indian Institute of Foreign Trade and Commerce has estimated that, internal demand of sisal fibre will be around 40,000 t, while annual production of sisal fibre hardly exceeds 300-500 t at present comprising public and private sectors.

Use and utilization

The main use of sisal fibre is for manufacturing of ropes and twines and other forms of cordage; although, considerable amount of fibre are also utilized for padding and upholstery and for mats as well as for bags and sacking. More uses includes sausage casings, reinforced plastics and building boards, carpets, crafts and speciality papers, different types of nets and brushes, straps of different use, ladies fancy purses and belts. *Microcrystalline cellulose* (MCC) derived from sisal are as good as other industrial MCCs used in medicine industry. Sisal plants with leaf spines can be used as *Live Fence* for controlling grazing by stray cattle/animals. Sisal plant parts contain 0.05-0.14% hecogenin, a glycoside of commercial importance. Hecogenin is one of the important precursors for the synthesis of steroid hormones (cortisone, cortisol, progesterone, stanozolol etc). Rough agave flower (*Agave scabra*) has the potential to partially replace alfalfa in diets for growing goats [Rangeland Ecol Manage, Vol. 61].