Project Completion Report

Manufacture of Jute Braided Cloth by Appropriate Design Incorporation in Braiding Machines

Jute Technology Mission (Mini-mission IV, DDS 7.1), Project No. 4

Sponsored by National Jute Board
Ministry of Textiles, Govt. of India

Submitted by

Indian Jute Industries' Research Association
17, Taratola Road, Kolkata-700 088

PROJECT INFORMATION

A. Project title	**Manufacture of Jute Braided Cloth by Appropriate Design Incorporation in Braiding Machines**
B. Project code	Jute Technology Mission (Mini-Mission-IV, DDS 7.1/2)
C. Project Team & Contact Details	**i) Dr. Mahuya Ghosh (PI)** :mghosh@ijira.org; +91 33 6626 9217 **ii) Mr. Debkumar Biswas** :dbiswas@ijira.org; +91 33 6626 9217 **iii) Mr. Arindam Das** :arindamdas@ijira.org; +91 33 6626 9217 **iv) Dr-Ing. P.K. Banerjee (Advisor)**
D. Implementing Institution & Contact Details	**Dr. Prabir Ray, Director** **INDIAN JUTE INDUSTRIES' RESEARCH ASSOCIATION (IJIRA)** 17, Taratola Road, Kolkata- 700088 Tel:+91 33 66269200/29/17, Fax: +91 33 66269204/ 227 E-mail: ijiraweb@ijira.org, director@ijira.org Web: www.ijira.org
E. Date of commencement	9th June 2008
F. Date of completion	March 2013
G. Approved Budget	Rs. 40.00 lakh

ACKNOWLEDGEMENT

Indian Jute Industries' Research Association (IJIRA) sincerely acknowledge the constant financial support and encouragement extended by the National Jute Board, Ministry of Textiles, Govt. of India for carrying out R&D activities of the project entitled "**Manufacture of Jute Braided Cloth by Appropriate Design Incorporation in Braiding Machines**" under Jute Technology Mission (Mini Mission IV, DDS 7.1/2).

IJIRA wish to express sincere gratitude to The Agri-Horticultural Society of India, Kolkata and Sahayog Hortica (P) Ltd., 24-Parganas (S) for providing their infrastructural facilities and valuable suggestion during carrying out the field trials at their esteemed horticultural nurseries.

IJIRA sincerely express gratitude to Dr. P.K. Pramanick, the Director of Horticulture & Mission Director, State Horticulture Mission, Department of Food Processing Industries & Horticulture, Govt. of West Bengal, for providing necessary information and suggestions regarding production of planting materials/ seedling in West Bengal and scopes of jute nursery sapling bags.

IJIRA express deep sense of gratitude to M/s Gloster Ltd. for their help in understanding of jute rove yarn preparation and cost estimation exercises.

IJIRA would also like to especially thank Dr. B.S. Mahapatra, the Director, Central Research Institute for Jute and Allied Fibres (CRIJAF), Barrackpur and the concerned Principal Scientists for providing their precious suggestion and co-operation in carrying out soil analysis experimentation.

Direct and indirect contributions and support of all the concerned persons and organizations that led to the successful completion of the project are gratefully acknowledged.

CONTENTS

1. EXECUTIVE SUMMARY

Jute fibre has several encouraging attributes, like, good mechanical properties, high moisture absorbing and retaining capacity, and capability to bio-degrade along with its low-cost and ample availability in India. These factors render jute as extremely suitable raw material for diversified applications in the emerging areas of technical textiles apart from its traditional uses.

Braiding is a traditional narrow fabric-manufacturing technology. It has some edge over commonly used conventional weaving technology for fabric manufacture. These are:

i. Simpler single stage process and no preparatory processes for yarn before braiding as those required for weaving
ii. Circular braiding directly produces tubular fabric/ sleeve - side-stitching is not required
iii. Capable of handling wide range of raw materials, viz., yarns/ tapes/ roves/ wires
iv. Lower production cost as lesser number of machinery involved

Hence, in the present work, an endeavour was made to develop cost-effective jute braided products which would have potential use in agrotextile and other technical applications.

Jute woven sapling bag is a natural 'agrotextile' product for growing saplings instead of ecologically unfriendly polythene bags (polybags) used in different horticulture, forestry and agro-forestry nurseries. This product has huge domestic and export market. If 50% of the requirement (predicted by the Working Group on Horticulture and Plantation Crops) of planting materials for fruits and spices are produced and transported within jute sapling bags then the projected requirement of such bags is 1000 million by the year 2012. Additionally, these bags can be usefully employed for raising and transporting costly ornamental saplings and cactuses (xerophytes).

Based on the foregoing discussion, it was decided to develop jute sapling bags employing circular braiding technology as this product comes under narrow tubular fabric category. The dimension of the product aimed at is 9" (length) x 6" (flat width).

To this end, a jute braiding machine along with a multiple yarn winding unit was designed. This was done in accordance with the requirements of the intended products incorporating facilities for wider research scope and subsequently fabricated. It is a 48-spindle circular braiding machine having provision for inserting 24-axial materials. The fabric take-up speed and braiding speed are independently controllable with the aid of Programmable Logic Control (PLC) system. The machine is capable of producing continuous jute braided sleeves of maximum width of 6 inches and sleeves of lower width can be easily produced. During the product development activities, several modifications on this machine were carried out as needed, e.g,

- Suitable insertion of twenty-four flexible plastic pipe guides for axial materials to protect them from getting rubbed in between the oppositely moving sets of braiding yarns

- Fabrication and fitting of 24- capstan type mild steel tensioners for axial materials

- Fabrication and fitting of axial material feeder assemblies capable of accommodating larger packages.

To minimize the soil loss during handling and transportation, the cover of these tubular fabrics should be as high as possible. In the final approach of product development, a novel material, named as, '***jute tape***' of suitable dimension and strength, was introduced as the axial material during braiding to achieve simultaneously high fabric cover and low mass in the product. This yielded *a tri-axially braided sleeve which is an axial assemblage of several 'jute tapes' bound in position by minimum of number of braiding yarns*. This concept necessitates development of 'jute tape' from jute of medium or lower batch quality, whereby these tapes should be as thin and as wide as possible while exhibiting a strength that should be sufficient to withstand the strains of braiding. To this end, the jute tapes were prepared one at a time from light weight jute sliver (60 lb/ spyndle) by adhesive (e.g., starch) treatment employing laboratory padding mangle in Pilot Plant. These tapes along with standard 8 lb /spyndle jute yarns (as braiding yarns) were employed to prepare jute braided sleeves. At this stage, the produced braided sleeves were reasonably thin with almost half the mass per unit area than that of the sleeves produced with jute roves. The novelties of jute tape-based technology are:

- As axial material, *jute tapes* provide main body of the fabric and hence play the central role instead of braiding yarns

- Generally, axial materials act as reinforcing agent in braids; but here, jute tapes are primarily employed to achieve better fabric cover assigning secondary importance to rigidity

- Preparation of jute tape is simple involving existing jute/ textile machinery only

To prevent soil-loss and avoid frayed-edge, sapling bags were prepared by doubling the above-mentioned jute tape-based sleeves in a specific manner and closing one end suitably. Mass per piece of the bag is **40 g** approximately.

Two-stage field trials were carried out employing the developed jute braided sapling bags, namely, preliminary field trial at IJIRA premises and final field trial in the nursery of the Agri-Horticultural Society of India, Kolkata. The following are the outcomes:

a) Soil analysis experimentation revealed that bio-degraded jute bag has enhanced soil-nutrient level by enriching the soil considerably with *organic carbon, phosphorus* and *potassium*.
b) Comparative performance study of developed jute braided sapling bags vis-à-vis nursery polybags with respect to selected morphological traits of seedling reveals the following:
   (i) Growth of seedlings is similar or comparable in both type of sapling bags with respect to stem base diameter and stem height.
   (ii) Formation and unrestricted growth of healthier root network in jute braided bags vis-à-vis that in polybags. Natural porosity of the jute bags causes better air circulation and water drainage inside the bag which help to grow healthy root system.
   (iii) Jute braided sapling bags performed much better than polybags in respect of soil-loss from bags during nursery care.

To make the product and the process developed so far commercially acceptable, multiple jute tape production is essential. For manufacturing multiple jute tapes of suitable dimension, a machine should be properly designed and fabricated accordingly which should contain the following parts:

a) Multiple sliver feed arrangement
b) Adhesive application and two-roll single nip squeezing unit
c) Drying unit
d) Take-up unit
e) Winding unit

The feed unit should be capable of feeding maximum number of slivers which would be determined by the width of squeezing rollers and that of individual sliver. The adhesive application unit would be roller-nip feeding type to reduce the amount of applied adhesive and thereby amount of moisture to be evaporated for drying. The heart of the present problem is to design a proper and efficient drying system as production rate is directly related to it. A properly designed enclosed hot air based drying system may be suggested for this purpose as contact (conduction process) drying would damage the very light weight jute tapes and radiation drying would not be cost-effective due to its extremely slow rate of drying and high capital cost. In this context, a model system was prepared by suitably modifying the existing laboratory padding mangle which is capable to demonstrate the basic principle of multiple jute tape manufacture. Optimization of the production and properties of these tapes is of vital importance.

The price per piece of the developed jute braided sapling bag of dimension, 9" (length) x 6" (flat width) has been estimated to be Rs. 2.60/- approximately.

Based upon related calculation on machine running efficiency, commercially adoptable jute braiding machine should have two-third of the braiding yarn bobbin capacity of the present braiding machine and separate motor arrangements for braiding and fabric take-up operations without any Programmable Logic Control (PLC) facility. Evidently, the size, power consumption and cost of the commercial version would be lower than the present machine.

It is possible to generate braided sleeves of varying dimensions on the developed machine by manipulating the three variables related to jute tape, viz., width of each tape, total number of tapes and inter-tape spacing in conjunction with the machine rpm and take-up speed. The sleeves so produced on a suitable braiding machine can in principle be employed for protection, storage and transportation of natural materials. Sapling bag is one such example. With suitable manipulation one can create open mesh structures for storage and transport of fruits and vegetables, replacing the plastic mesh materials commonly found in outlets such as Mother Dairy. Indeed the total technology (economic production of adhesive bonded tapes followed by suitable braiding of such tapes into sleeves and finally fabrication of the desired products from such sleeves) once properly developed can open up an entirely new vista of jute diversified products.

Similarly such sleeves, suitably designed, can be used as Geotextiles in the form of Vertical Drain (VD) used for accelerating soft soil consolidation before construction over thick strata of soft saturated soil. This drain product has huge demand all over the world in different land reclamation/ ground improvement projects. To this end, an endeavor was made to prepare braided VD samples in the braiding machine employing 28 lb/spyndle jute yarns for forming the ‘drain sheath’ and 260 mpk (meter per kg) coir yarns as ‘drain core’. Subsequently, the VD sample was subjected to testing for its dimensional and water permeability properties. This reveals that the sample is a representative of ‘vertical drain’. However, actual field trials of the product in land reclamation / ground improvement projects are must to establish its efficacy. Hence, further research is needed to modify it properly for ensuring desired field performance which is beyond the scope of the present project.

2. INTRODUCTION

Jute is a reasonably robust, hygroscopic and bio-degradable natural fibre. It is also low-cost and available in abundance in our country. These attributes render jute as eminently suitable for uses in the field of agrotextiles, geotextiles and other emerging technical textiles in addition to its traditional packaging application. The present project is aimed at development of braided products from jute which would have potential use in agrotextile and other technical applications.

Jute sapling bags/ sleeves are a type of 'Agrotextile' which are employed or can be usefully employed for raising saplings with care instead of polythene bags/ sleeves in different horticulture, forestry and agro-forestry nurseries. This natural 'agrotextile' product would help in doing away with ecologically unfriendly plastic bags. Additionally, these plastic bags causes some serious problems to seedling health, e.g., root coiling (unhealthy growth of root network), poor ventilation, extremely hot/cold inside temperate, etc. On the contrary, jute being biodegradable natural environment friendly and hygroscopic fibre, jute sapling bags would have several advantages over sapling polybags.

Advantages of jute sapling bag over sapling polybag:

a. Jute sapling bags are expected to provide a healthier microclimate for development of root network of the saplings.

b. The sapling and the jute sapling bag can be transplanted in situ in the field, thus avoiding any problem of disposal.

c. The jute sapling bag is also expected to decay within the soil in due course of time, providing added nutrition. The decomposed biomass would itself act as a green manure facilitating further growth of the sapling.

d. It would allow excess water to easily pass through the container itself.

e. Fibre hairs protruding out from jute fabric surface should cover pores of the fabric itself to certain extent. This would help in resisting soil particle loss during transportation from the nursery sleeves/ bags made of jute fabric.

To this end, jute woven sapling bag was developed from jute woven Hessian fabric at Indian Jute Industries' Research Association for nursery use (Choudhury, 2002). But, the associated nursery bag manufacturing technology was lengthy, multi-staged weaving process and subsequent processing stages of cutting and sewing.

On the contrary, braiding technology produces circular / tubular fabric, i.e., sleeves directly utilizing yarns received from spinning department vis-à-vis weaving. It has the following technical advantages over conventional weaving:

v. Simpler in operation and no preparatory processes for yarn before braiding as those required for weaving - single stage process

vi. Directly produces tubular fabric- side-stitching is not required

vii. Lower tension on yarns - (a) low yarn breakage rate, (b) capable of handling inferior quality inexpensive yarn

viii. Lower production cost as lesser number of machinery involved, lower power consumption and manpower involved.

As a result, braided tubular structures or sleeves can be manufactured from jute yarns which are likely to be cheaper than those made from jute woven fabrics. Only a suitable and simple bottom closer operation (e.g., hand-knotting) will suffice to convert the sleeves into desired tubular braided products which can also be employed for other end-uses such as carry bags.

In this context, an endeavor has been made by adopting braiding technology to develop these jute braided nursery sapling sleeves/ bags.

Another technical textile product, namely, *vertical drain (VD)* is a 'geotextile' product used for accelerating soft soil consolidation before construction over saturated cohesive soil (e.g., marine clay). Synthetic VDs produced from diverse synthetic materials and having various geometric shapes in cross-section are commercially used world over (Bergado et. al., 1994; Banerjee et. al., 1997; Kuberan, 2004). But, performance of these non-eco-friendly drains is severely affected through kinking of their relatively rigid cores caused by settlement of soil. However, highly flexible and eco-friendly natural fibre-based such product, namely, 'fiberdrain' composed of jute burlaps/ woven fabrics and coir yarns performs better than the synthetic ones under kinked condition. Additionally, the plastic drains are produced by involving a large of machines and processes. Method of manufacturing 'fibredrain' too involves a series of discontinuous steps. Hence, a single step manufacturing process by which a VD can be produced directly from yarns at a much faster rate would be desirable. ***In the era of land scarcity, the market of this product is huge across the world in various land reclamation and ground improvement projects.*** Hence, an attempt has been also made to develop samples of braided VD employing jute yarns for making the braided 'sheath' part meant for soil filtration and coir yarns for the 'core' part meant for transporting and discharging out the pore water of surrounding soft soil quickly.

3. OBJECTIVES OF THE PROJECT

(i) To manufacture jute braided cloth on a braiding machine

(ii) To manufacture jute braided sleeves of different widths and constructions

(iii) To optimize the structures and dimensions of jute braided cloth according to end use requirements

(iv) To study the structure – property relationships of jute braided cloth

4. LITERATURE SURVEY

4.1 Literature Summary

A literature survey was carried out to understand the braiding technology, nursery seedling care practices employing sapling bags, and different nursery seedling quality/ health assessment processes.

Braiding is a simple but versatile single-stage narrow fabric manufacture technology vis-à-vis weaving. This technology does not require yarn preparatory processes, e.g., warping, sizing and beaming, weft package preparation (e.g. pirn/ cop) etc. as needed for weaving. Among different types of braiding processes, tri-axial circular braiding process would produce tubular fabric or sleeve having some extra cover and reinforcement along the sleeve axis than braided sleeve without axial material.

Among different nursery practices to produce healthy seedlings in large-scale, e.g., nursery bed/ bare-root nursery, polybag (a typical container) and root trainer nursery practices, use of sapling polybags is very popular, especially in India. Though polybag nursery practice has several advantages over bare-root nursery system, it has also some severe drawbacks amongst which its hazardous impact on environment is the most prohibitive one. Almost a decade back, Indian Jute Industries' Research Association has developed nursery sapling bags from jute woven fabric and obtained better performance than polybags from field trial.

Nursery seedling quality assessment is based upon seedling morphological and physiological characteristics/ traits. Being easier to measure, morphological traits are generally used to assess seedling health and predict field survivability after transplantation. Amongst various morphological characteristics, height and stem diameter are the two characteristics most commonly examined on seedlings in forest nurseries.

Nursery seedling growing bags/ containers should have some dimensional attributes which would help to grow seedlings planted in it. According to several related literature, medium (≈500-600 cm^3) and large volume (>1000 cm^3) containers would produce better quality seedlings. One significant aspect is the ratio of depth to diameter of the bag. Reported literature reveals that the optimum value should be 4.

Related information collected from different literature are provided in detail below.

4.2. Braiding Process

Braiding is an extremely old, simple, but versatile and very different textile process of narrow fabric formation vis-à-vis weaving and knitting. The three mentioned processes of fabric manufacture are distinguished from each other in the manner of insertion of yarn into the fabric and their interlacement. Brunnschweiler (1953) defined ‘braiding’ as:

The production of ribbonlike or ropelike textures by the interlacing of one set of threads in such a manner that no two adjacent threads make complete turns about each other.

Braid is “a narrow tubular or flat fabric produced by interwining a single set of yarns according to a definite pattern” (Callaway textile dictionary, 1947). As per ASTM D123-49, braid is “a structure produced by interlacing several ends of yarn in a manner such that the paths of the yarns are not parallel to the braid axis”.

There are different types of braids which can be generated in different braiding machines (Fig.4.2.1.). According to Brunnschweiler (1953), these are Flat braids, Tubular or Round braids and Fancy braids. Adanur (1995) classified braiding as two-dimensional braiding- Circular and Flat, and three-dimensional braiding.

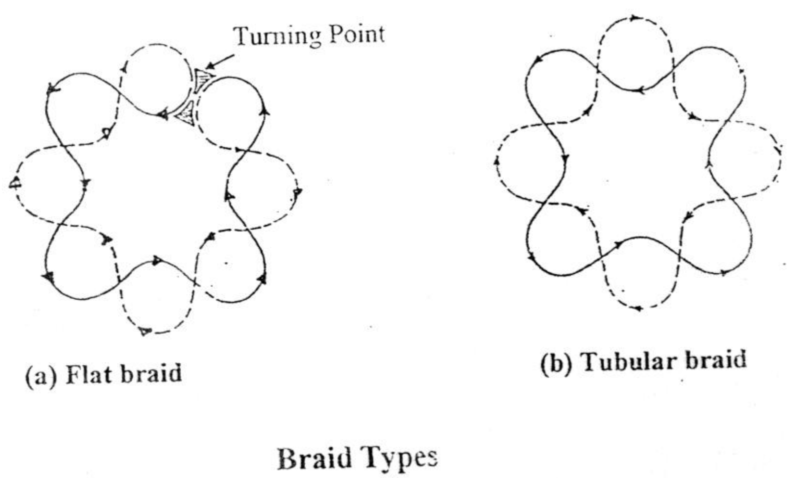


Fig. 4.2.1. Braid Types (after Thompson & Bick, 1952)

In the present case, the discussion would be concentrated on Tubular braids only. A tubular braided fabric is produced on a circular braiding machine (Fig. 4.2.2) in which spindles carrying strands of yarns move in a horizontal/ or vertical plane along a serpentine (or sinusoidal) path around the periphery of a circle. In the simplest system, one set of spindles rotate clockwise along the periphery of the circle while the other set having equal number of spindles as those of formers rotate anti-clockwise. These spindles carry yarn wounded flanged bobbins. When a clockwise moving spindle S1 approaches an anticlockwise moving S2, both execute an additional radial motion. One of these two, say S1 moves away from the centre of the circle while the other (S2) moves towards the centre. Having thus avoided collision and crossed each other, they return to the periphery to continue their journey in opposite directions. The interlacement between the strands carried by the spindles S1 and S2 result out of this relative rotation of the spindles about each other although at a location far removed from the plane of these spindles. The braiding point at which yarns from all spindles merge and get converted to the fabric, is analogous to the fell of a woven cloth. In the resultant fabric at the braiding point, the strand of S1 would appear above that of S2 forming an interlacement very similar to that of a woven fabric with the difference that the crossing threads in the braided fabric might be highly acute or obtuse to each other (Banerjee, 2003).

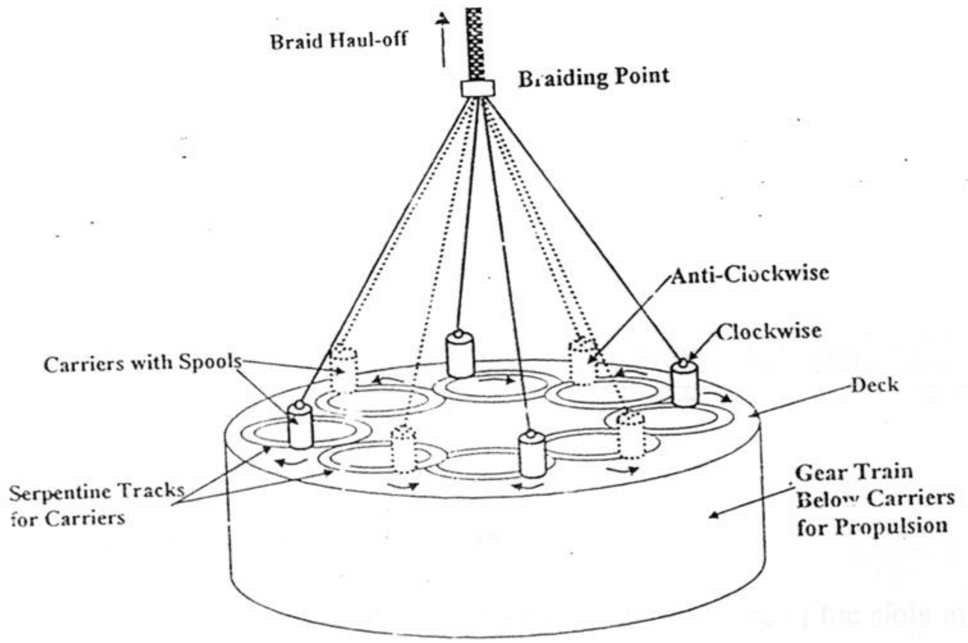


Fig.4.2.2. A typical Braiding Machine

Three simple braid constructions (i.e. in respect of style of yarn interlacements- equivalent to weave) formed on a braiding machines frequently are Diamond braid (with a 1/1 intersection repeat), Regular braid (with a 2/2 intersection repeat) and Hercules braid (with a 3/3 intersection repeat) (Fig. 4.2.3). The equivalent woven fabric constructions, when viewed with a bias of 45°, are 1/1 plain, 2/2 twill and 3/3 twill. Amongst these, the Regular braid is by far the most popular construction (Fig. 4.2.4).

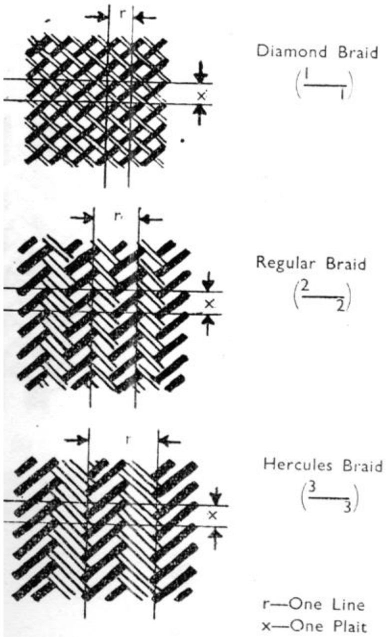


Fig. 4.2.3. Different braided weaves (after Brunnschweiler, 1953)

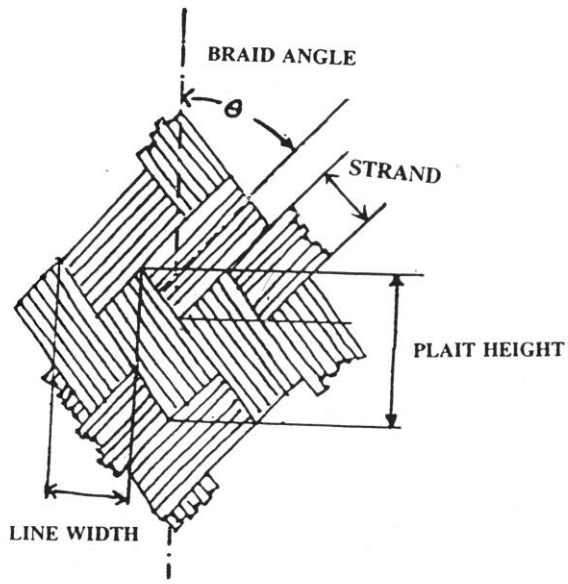


Fig. 4.2.4. Plan of regualr braided structure (after Banerjee, 1997)

Tri-axial braiding is done by introducing a third set of yarns (axial yarns) parallel to the braid axis during braiding and a tri-axial braid is created (Fig.4.2.5). These yarns would not take part in the braiding process but would only get entrapped in the braided cloth thus remaining perfectly aligned along the braid axis imparting certain rigidity (Banerjee, 1997) and cover to the fabric.

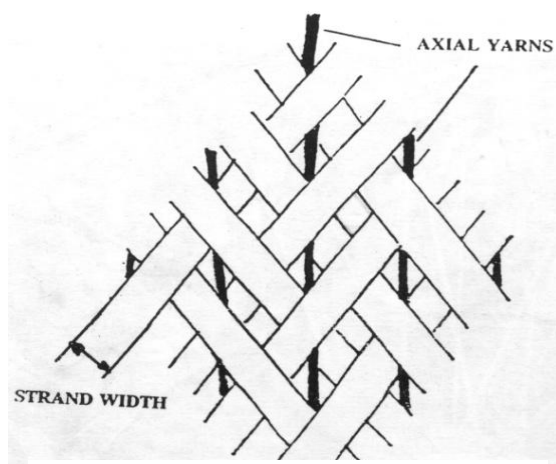


Fig. 4.2.5. Tri-axial Briaded Sturucte (after Banerjee, 1997)

Zhang et al. (1997) reported that the cover factor of a two-dimensional braided fabric depends on three variables: braid angle, helical length, and braid diameter; however, only two of the three are independent because of an equation of constraint. When braid diameter is held constant by braiding on a constant-diameter 'mandrel', the cover factor is increased by decreasing the helical length or increasing the braid angle. Additionally, the cover factor is directly related to the fabric width as a single independent variable. At this point, it should be mentioned that braiding of shapes can be carried out by feeding a mandrel through the centre of the braiding machine at a controlled rate.

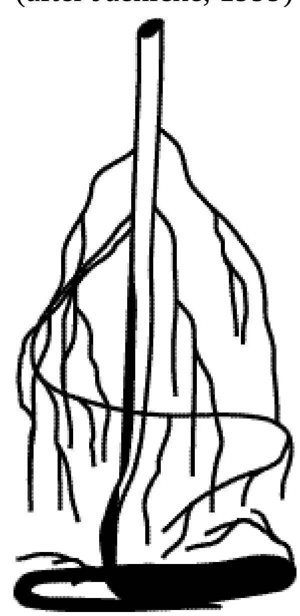
In the case of tri-axial braids, axial material (yarn or tape) would positively contribute to the braided fabric cover.

4.3. Nursery Sapling Sleeves/ Bags

Most tree nurseries either produce bare-rooted seedlings or use polythene bags (typical container). Bare-root nurseries are often recommended for on-farm nurseries because of the smaller capital investment needed. For a research nursery, always containerized systems should be considered unless bare-rooted systems for research are needed. Container seedlings are relatively tolerant to physical abuse and mishandling, transplanting stress and are suitable for poorer sites in comparison to bare root seedlings (Jaenicke, 1999). Among different nursery seedling growing containers used, polythene bags/ polybags are most commonly used to raise seedlings/ saplings in agricultural, horticultural and forestry nurseries in developing countries, like India. They are usually made of black/transparent polyethylene and have several drainage holes at the bottom (if they don't, holes can be made using a paper punch). They come in various gauges and volumes between 0.3 and 45 litres. The size of polybag selected depends on the plants to be raised, their purpose and size. For example, in India's Andhra Pradesh state, the forest departments prefer large (at least 500 ml) polybags for fruit trees, e.g., grafted tamarind, emblica, custard apple, etc (Jaenicke, 1999). Ravishankar and Ramasubramanian (2004) also suggested that polythene bags should be used to raise the mangrove saplings in the mangrove nursery. Though the polythene containers are handy and economical, they have some serious inherent problems:

i. Causes root coiling or spiraling (i.e., plant roots tend to grow in spirals) (Fig. 4.3.1). Seedling roots grow geotropically, but if they do not meet any physical obstruction, they may tend to grow laterally around the side of the container once they hit the smooth inner surface. Root spiraling is very common in flat-bottomed, smooth walled polythene containers. This will inevitably lead to plants with restricted growth, poor resistance to stress and wind-throw and even early dieback due to ensnarled root masses or pathogens.
ii. Raising seedlings in polybags often causes a deformed or J-shaped taproot of the planting stock produced and may develop to mature trees with poor anchorage in the field.
iii. It is mostly poorly aerated. Uneven wetting and drying occurs in the container.
iv. Lateral fibrous root growth is poor.
v. Bags often break, and the root system of the plant could be easily damaged.
vi. Disposal problem after transplantation in field
  - impact on environment
vii. Due to its inherent nature, temperature inside the polybag sometimes goes up in tropical areas and ice formation is observed in high altitude zone. These cause high degree of mortality in young plants.

Fig. 4.3.1. Root spiralling in polythene bag container (after Jaenicke, 1999)



Jute woven nursery sapling bag was developed at Indian Jute Industries' Research Association for nursery use (Choudhury, 2002). Ten thousand such jute sleeves of size 9" x 6'' (prepared from 11 x12–8.9 oz Hessian fabric) were tried by Land Use & Environment (N) Division, Department of Forest Environment and Wildlife, Government of Sikkim at their 8 nurseries in different climatic and altitudinal zones. The types of plant used were Walnut, Broomstick, Agava, Cherry, Juniper, Tooni, Lapsi, Sunal etc. The soil contained composed manure mixed with cow-dung and sand. The study with regular monitoring continued for 1 year from 15.05.2001 to 14.05.2002. The findings of the study as recorded by the Department are stated below:

- Distribution of water supply within the soil in the jute sleeve was uniform due to the intrinsic characteristics of jute.
- The delicate seedlings often die due to excess heat generated in poly sleeves in the tropical areas, but it did not occur in jute sleeve due to aeration and thermal property of jute.
- No ice-formation took place in jute sleeves but it occurred in its poly sleeves counterpart.
- Handling of jute sleeve was more convenient than poly sleeve for filling and transplanting.
- The growth and survival rate of seedling appeared to be much higher in jute sleeve (90%) than in poly sleeves (70%)
- The protrusion of roots of planted seedlings had access through the openings of the fabric and remained undisturbed during transplantation.
- The temperature inside the bags remained fairly constant as compared to poly sleeves. The condensation inside the poly sleeves was more during daylight and it did not occur inside the jute sleeves.
- In rainy days, no water-logging was indicated in jute sleeves, which was occasionally observed in poly sleeves.

From the findings of the study it reveals that jute sleeve performs better than poly sleeve in nursery use in all respects. Based on the efficacy and eco-compatibility of the product Forest and Environment Department has proposed to use about 40,000 jute sleeves commercially at three different divisions in Sikkim. But, these studies with jute woven sapling bags provided us only the qualitative performance aspects of this agrotextile.

4.4. Nursery Seedling Quality Assessment

According to related literature (Haase, 2008; Villar-Salvador et al., 2004; Trubat et. Al., 2010; Ferdousee et. Al., 2010), seedling quality assessment is based upon seedling morphological traits and physiological traits. In addition to this, a seedling's morphological characteristics can be considered a physical manifestation of its physiological activities whereas physiological quality depends on the seedling's internal functions. Morphological traits are more easily measured than

physiological traits. Consequently, morphological traits are commonly used in assessing seedling quality.
Several morphological traits which are commonly used in assessing seedling quality are provided below.

a) Root length (in cm) and volume (in cm^3)
b) Shoot length/ height (in cm) and volume (in cm^3)
c) Total seedling length/ size
d) Root Collar Diameter (RCD)
   - It is an important characteristic of a seedling. It is a measure of the seedling's survivability potential and also the parameter on which the seedling price is based. According to Clark et al. (2009), RCD had the highest correlations to nursery seedling quality and first-year field performance in the case of American chestnut (*Castanea 13entate*).
e) Shoot –to- root dry biomass ratio (S/R)
f) Number of first order lateral roots (FOLR)
g) Stem diameter at the point of cotyledon insertion point (embryonic leaf generation point)
h) Leaf area (in cm^2) and number of leaves
i) Number of nodules

- Lower the ratio of height to shoot dry matter weight, the more lignified the seeding and the greater is the field survival capability
- The Dickson Quality Index (DQI) is a tool to evaluate seedling quality as a function of (Binotto, Lúcio and Lopes, 2010):
  -Total dry matter (TDM)
  -Shoot height (SH)
  -Stem base diameter (SBM)
  -Shoot dry matter (SDM)-sum of stem base dry matter and leaf dry matter –and root dry matter (RDM), and is given by the expression:

  DQI = TDM (g)/ [SH(cm)/ SBD (mm) + SDM (g)/ RDM (g)]

  Its calculation computes robustness and biomass distribution while considering several important parameters.

Some researchers reported that nursery seedling growth significantly depends on container (e.g. polybag) sizes though the container size primarily depends on seedling type to be raised. Related literature reveal the following:

- Dumroese et al. (2011) reported that increasing container volume from 50 to 656 ml yielded *Acacia koa* seedlings with 200 % more height and stem diameter growth.

- According to Ferdousee et al. (2010), polybags of bigger sizes (23 cm x 15 cm size) are preferred for producing large and vigor *Leucaena leucephala* seedlings.
- Howell (2004) found that seedling growth attributes (size, biomass and leaf area) of the Cherrybark oak (*Quercus pagoda L.*) seedlings grown in medium (650 cm^3) and large (1250 $cm^{3)}$ containers were up to twice those grown in small containers (170 cm^3).
- Dominguez-Lerena et al. (2006) reported that the best indicator of seedling development in the nursery was the ratio of container depth to container diameter, and the optimum ratio was 4. Root density (root biomass/ volume) was inversely correlated with container volume but there was no correlation with either depth or growing density. The largest *Pinus pinea* plants were produced with container volumes of 300-400 cm^3, depth/ diameter ratio of 4, and growing densities of 200-300 seedlings/ m^2.

4.5. Vertical Drains

Pre-consolidation of the soil is essential to construct a structure (e.g., road, building, etc.) over sites underlain with thick strata of soft cohesive soil (e.g. marine clay, peaty clay, etc.). This process involves subjecting the soil mass to a compressive load with a view to effect a reduction in inter-granular space. An application of surface load results in a consequent increase in pore pressure in the saturated soil (Barron, 1948). This pressure can be quickly reduced by draining out water under pressure from the pore spaces (i.e., inter-granular spaces present in soil bulk), thereby transferring the compressive stress to the soil grains. Traditionally sand drains (i.e., vertical sand filled cylindrical holes) in combination with requisite surface loads were used for accelerating the consolidation process. But, proneness to clogging of such drains and associated high construction cost along with other limitations led to invention of Vertical Drains. Vertical Drains (VDs) starting with Kjellman's cardboard drains in 1937 and subsequently produced from diverse synthetic materials in different shapes in cross-section, have become gradually popular to be installed in the clay deposit to achieve the desired degree of consolidation within project duration by accelerating the consolidation process. This was happened because of these products' consistent qualities, ease of transport and installation, non-clogging potential, high discharge capacity and lower smear effect (Hansbo, 1979). In principle, such VDs are consisting of a filtering sheath of very fine spunbonded polyester or polypropylene fabric encasing a core made from diverse synthetic materials and having forms and shapes differing from one manufacturer to another. These drains should have the following characteristics: (1) ability to permit pore water present in the surrounding soil to seep into the drain, but simultaneously inhibiting/ limiting the ingress of soil fines into the core to prevent clogging, and (2) a means by which the collected pore water can be transmitted undisturbed along the length of the drain even at large lateral pressures. But, these synthetic/plastic drains are non-perishable by nature and would cause hazardous effect on environment on long-term.

To avoid environmental hazards associated with drain materials, use of biodegradable natural fibres like jute and coir in manufacture of VDs was started almost three decades back. A natural fibre-based VD, known as Fibredrain, was developed at the National University of Singapore, using jute and coir fibre and subsequently used in several projects involving treatment of soft marine, fluvial clays and peaty clays (Lee et. al., 1987; Lee et. al., 1989). These drains are used in various ground improvement projects in Singapore, Japan and other South-east Asian countries. The general form of 'fibredrain' is rectangular strip with some 80 mm to 100 mm in width and 8 mm to 10 mm in thickness. Four coir strands of 3 mm to 6 mm in diameter obtained from coir fibre are encased by two layers of jute burlap to arrive at the above dimensions. Three longitudinal stitches hold the coir strands in separate flow channels within the jute burlap. Robust and highly flexible nature of fibredrain would help to maintain its performance under kinked condition unlike synthetic ones.

The method of manufacturing synthetic VDs demands a large number of machines and processes. A series of discontinuous and labour-extensive steps are required for producing fibredrain as well. Hence, a new drain, termed as 'brecodrain' was developed at IIT Delhi using natural fibre materials (jute and coir) employing single step braiding technology (Banerjee et. al., 1997).

Another natural fibre drain known as straw drain board (SDB) has been recently developed in Korea (Kim and Cho, 2008). This drain is made up of straw strand and jute filter.

Relatively low cost of manufacture using indigenous material and local labour makes these natural VDs attractive in countries, like India where jute and coir are abundant.

Related References

Banerjee P K, Rao G V, Sampath Kumar J. P., 1997. Characterization of the brecodrain for soft soil consolidation, *Geosynthetics Asia'97*, 26-29 November, Bangalore, India, Vol. I, pp. VI.3-VI.24.

Banerjee P K, 2003. Geometrical relationships between structural and dimensional variables of a tubular braid, *Seminar on Textile Ropes and Cordages*; Department of Textile Technology, IIT Delhi, December, pp.23 – 39.

Barron, R.A., 1948. Consolidation of fine-grained soil by drain wells. Transaction ASCE, Vol. 2346, pp. 718-754.

Bergado, D.T., Chai, J.C., Alfaro, M.C., Balasubramaniam, A.S., 1994. Ground improvement by vertical drains. *Improvement Techniques of Soft Ground in Subsiding and Lowland Environment*, Rotterdam and Brookfield: Balkema, pp. 11-55.

Binotto, A.F., Lúcio, A.D.C., Lopes, S.J. 2010. Correlations between growth variables and the Dickson Quality Index in forest seedlings, Cerne, Lavras/ Brasil, Vol.16, No.4, pp. 457-464.

Brunnschweiler, D., 1953. Braids and braiding, *Journal of the Textile Institute*, pp. P666-P686.

Choudhury, P. K., 2002. Jute Agrotextile in Agriculture, Horticulture & Forestry**,** *Selected Book of Papers: Application of Jute Geotextile in Civil Engineering*, pp.80-90.

Clark, S.L., Schweitzer, C.J., Schlarbaum, S.E., Dimov, L.D., Hebard, F.V., 2009. Nursery quality and first-year response of American chestnut *(Castanea 16entate)* seedlings planted in the Southeastern United States, *Tree Planters' Notes*, Vol. 53, No.2, pp. 13-21.

Dumroese, R.K., Davis, A.S., Jacobs, D.F., 2011. Nursery response of *Acacia Koa* seedlings to container size, irrigation method, and fertilization rate, *Journal of Plant Nutrition*, Vol. 34, pp.877-887.

Ferdousee, N., Jabbar, F., Hossain, M.K, Rafiqul Hoque, A.T.M., 2010. Comparative Growth performance of *Leucocephala* seedlings raised in nursery bed, polybag and root trainers, *Proc. Of International Conference on Environmental Aspects of Bangladesh (ICEAB10)*, September, Japan, pp. 65-68.

Haase, D.L., 2008. Understanding forest seedling quality: Measurements and Interpretation, *Tree Planter's Notes*, Vol. 52, No. 2, pp. 24-30.

Hansbo, S., 1979. Consolidation of clay by band shaped prefabricated drains. Ground Engineering, Vol. 12(5), pp. 16-25.

Howell, K.D., 2004. Nursery practices influence seedling morphology, field performance, and cost efficiency of containerized Cherrybark oak, *Southern Journal of Applied Forestry*, Vol. 28, No. 3, pp. 152-162.

Jaenicke, H., 1999. *Good Tree Nursery Practices: Practical Guidelines for Research Nurseries*, International Centre for Research in Agroforestry, Nirobi, Kenya.

Kim, J.H., Cho, S.D., 2008. Pilot Scale Field Test for Natural Fiber Drain, *4th Asian Regional Conference on Geosynthetics: Geosynthetics in Civil and Environmental Engineering: Geosynthetics Asia 2008*, June 17-20, Shanghai, China, p.409.

Kuberan, R., 2004. Improvement of a deep clay deposit using prefabricated vertical drains in Mekong Delta, Proc. Of Geosynthetics Asia 2004: Geosynthetics- New Horizons, New Delhi, pp. 301-310.

Lee, S.L., Ramaswamy, S.D., Aziz, M.A., Das Gupta, N.C., Karunaratne, G.P, 1987. Fibredrain for consolidation of soft soils. *Post-Vienna Conference on Geotextiles*, Singapore, pp. 238-258.

Lee, S.L., Karunaratne, G.P, Das Gupta, N.C., Ramaswamy, S.D., Aziz, M.A., 1989. A vertical drain made of natural fibre for soil improvement projects, *Proceedings of the International Workshops on Geotextiles*, 22-29 November, Bangalore, India, Vol. 1, pp. 271-276.

Mangaoang, E.O., Cedamon, E.D., Pasa, A.E., 2004. Cost-effective systems for seedling production and tree farm establishment, *ACIAR Smallholder Forestry Project*. P107.

Thompson, A., Bick, S., 1952. *Narrow Fabric Weaving*: Chapter 12: Braiding, pp. 218-233.

Trubat, R., Cortina, J., Vilagrosa, A., Cortina, J. 2010. Nursery fertilization affects seedling traits but not field performance in *Quercus suber* *L.*, *Journal of Arid Environments*, Vol. 74, pp.491-97

Villar-Salvador, P., Planelles, R., Enriquez, J., Rubira, J.P., 2004. Nursery cultivation regimes, plant functional attributes, and field performance relationships in the Mediterranean oak *Quercus ilex L. Forest Ecology and Management*, Vol. 196, pp. 257-266.

Zhang, Q., Beale, D., Adanur, S., Broughton, R.M., Walker, R.P., 1997. Structural analysis of a two-dimensional braided fabric, *Journal of the Textile Institute*, Vol. 88, No.1, pp. 41-52.

5. NEED-BASED ASSESSMENT/ MARKET SURVEY

To make the project commercially successful a need-based survey of the market was carried out. The collected information has been collated and reported in the following sections.

5.1.Objective of the Survey

To find the current volume of sapling bags/sleeves for nursery use as also a rough estimate of the price they command.

5.2. Market Survey for Jute Sapling Bags/ Sleeves

The world market for technical textiles was estimated to be around 107 billion USD (in 2005) out of which 'Agrotech' accounts for 10 billion USD (TECHNOTEX-2009). According to Dr Pitam Chandra, Director, Central Institute of Agricultural Engineering, Bhopal (Report on TECHNOTEX-2009), agriculture is the largest occupation pursued in India and he concluded from this that the consumption of 'agrotextiles' (i.e., technical textiles in agriculture) can be increased to almost 50 % of the current world consumption of 'agrotextiles' (i.e. 1 million tons). Another source (Mathur, 2009) reveals that the 'agrotextile' market is expected to grow from 16, 15,000 tonnes (USD 6.5 billion) in 2005 to 19, 58,000 tonnes (USD 8.1 billion) in 2010, at an average growth rate of 3.9 % per annum. Developing countries like India with CAGR of 7.8 % are expected to witness sharp growth in demand for 'agrotextiles'. Gudiyawar and Gotipamul (2011) have reported that the market size of 'agrotextiles' in India is expected to increase from Rs. 553 crore in 2007-08 to over Rs. 1300 crore by 2012-13.

The Government of India has already declared horticulture industry as a priority area, providing a number of fiscal reliefs, thereby, encouraging commercialization and value addition to the horticultural products. Financial incentives were started in the Eighth Plan with an outlay of Rs 1 000 crores in the Central budget. This pace was continuously upgraded to 50 percent and 100 percent increase during Ninth and Tenth Five Year Plans, respectively. The Horticulture Technology Mission (HTM) for the Northeast (subsequently covering all hill states in Western regions also) and the National Horticulture Mission (NHM) launched by the Government of India (ending in 2012), are two well funded programmes to boost the horticulture industry in the entire country. Till December 2007, an amount of Rs 24,755 million was released to 18 states, 2 Uts and 11 national level agencies for implementation of the scheme. During the period, 1,549 new nurseries were set up and 0.76 million hectares were brought under new plantations of various horticultural crops (Ghosh, 2009).

It is reported in The Hindu that "the Green India Mission, part of India's plan to fight climate change, proposed to double the area being taken up for afforestation and eco-restoration over the next decade. The first draft of the Mission projects an ambitious target of 20 million hectares by 2020, at a cost of Rs. 44,000 crore. Public consultations will be undertaken across the country from June 2011, subsequently the draft will be finalized" (The Hindu, 2010).

In India, the forest departments of almost all the states are involved in the protection and afforestation of mangroves (Sengupta and Desa, 2001). But, it is clear that unless local communities are also involved in the raising of nurseries and rehabilitation of damaged mangrove wetlands, the tasks of conservation and restoration will not be accomplished speedily and effectively. To this end, Andhra Pradesh Government in collaboration with M. S. Swaminathan Research Foundation (an non-governmental organization) has undertaken an exercise on regeneration of mangrove forests and degraded wetlands in estuaries of Godavari and Krishna river adopting nursery-raised sapling technology and good nursery practices, like jute sack/or bag and polybag nursery practices. The mangrove nursery which was raised jointly by Andhra Pradesh Forest Department and MSSRF for restoring about 1,500 ha has the capacity to raise 1, 20,000 saplings per year. It has 80 sunken beds of 10 x 1 x 0.3 m (LBH respectively). Each bed can hold 1500 bags (Ravishankar and Ramasubramanian, 2004).

Moreover, M. S. Swaminathan Research Foundation also has undertaken various large exercises namely, restoration of bio-shields in coastal areas of the southern states of India, e.g., Andhra Pradesh, Tamil Nadu, Kerala and Orissa; biodiversity conservation, utilization and enhancement; ecological restoration and ecosystem monitoring, etc. During 2008-09, in the field of Coastal System Research, over 300 hectares of mangrove plantation were raised in partnership with fishing families. Over one million mangrove seedlings were planted and a mangrove bio-shield was established in about 150 ha. This work covers 21 villages in Tamil Nadu and Andhra Pradesh. Additionally, Women Self Help Groups (SHGs) has formed bio-shield nurseries. They run 23 backyard nurseries, 14 individual nurseries and one community nursery for mangrove and non-mangrove plants at Keelavanjore, Chandrapadi, Nethyalvasal and Pudukuppam. Consequently, there is a huge scope of establishing more new nurseries in these states to supply the quality planting materials (e.g., seedlings, cuttings, etc.) [Nineteenth Annual Report 2008-2009]. Evidently, demand of nursery seedling bags would be high.

Since 1997, Forest Department of India in co-operation with various Government Agencies and civil society groups has undertaken “Annual Greening Action” scheme, to carry out afforestation programs in Capital Delhi. To this end, green cover of Delhi has been increased from30 sq.km to 300 sq. km in last 10 years (Fig. 5.2.1). The related statistics on plantation target and achievement for saplings are listed in Table 1. Additionally, two Biodiversity parks namely Yamuna Bio-Diversity Park and Aravali Bio-diversity Park are being developed (Department of Environment, 2010).

In this context of infrastructural development and extension in Horticulture sector as well as Forestry in India, the demand for nursery sapling bags/ sleeves for raising saplings and their transportation to the destined field are huge and would increase sharply.

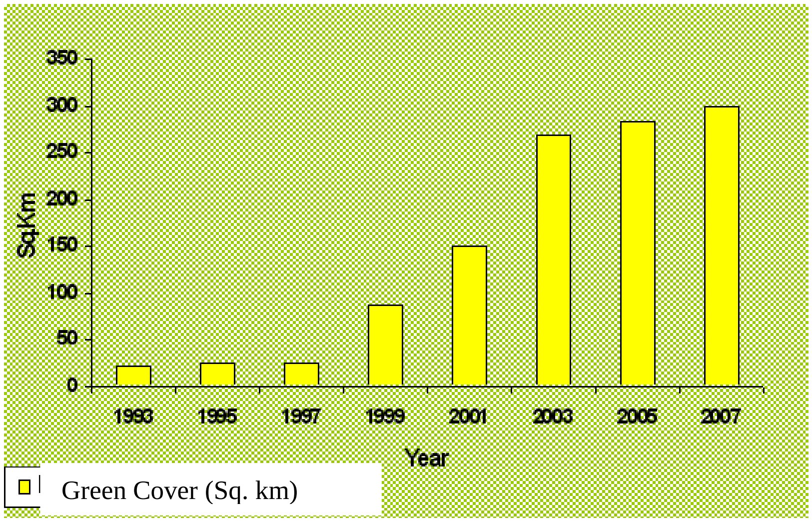


Fig. 5.2.1. Increase in Green Cover in Capital Delhi

Table 1: Plantation Target & Achievement (Saplings in Millions)

Year	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010
Target	0.950	0.985	1.045	1.254	1.556	1.711	1.89	1.348	1.14
Achievement	0.950	0.920	1.144	1.353	1.666	1.845	1.8	1.137	-

The survival rate of nursery raised seedlings in restoration areas is high (90%) when compared to the direct dibbling of seeds/ propagules. This is due to the fact that nursery-raised saplings have a well established root system, as they are maintained for 6-9 months in the nursery (generally from October to July) under simulated conditions, before being transplanted in the degraded areas (Ravishankar and Ramasubramanian, 2004). However, teak seedlings need to be maintained for 12 to 18 months for preparation of stumps, which are planted out directly during May-June (Mohanan and Sharma, 2005). To this end, in India, since 1970 polythene containers (polybags/ or polysleeves) have been widely used for raising forest nursery seedlings. Polythene containers of different sizes are used for either direct seedling or transplanting the bare root seedlings. Polybags are usually made of black polyethylene and have several drainage holes at the bottom. Polysleeves made from the same material are cut from a continuous roll and have no bottom. They come in various gauges and volumes between 0.3 and 45 litres.

Ravishankar and Ramasubramanian (2004) reported that, jute sacks or polythene bags of 5”x8” were employed to raise the mangrove saplings in the nursery for restoration of Mangrove Forest Programme in Andhra Pradesh (in the estuaries of Godavari and Krishna rivers).

Some related literature reveal the following statistics for potential use of jute braided nursery sapling sleeves/ bags:

1. The annual production of planting materials (i.e. seedling/sapling) in West Bengal is 1,06,00,000 approximately. This is the total production from the Governmental Agriculture, Horticulture and Forestry sector nurseries (Pramanick, 2009).

2. The Working Group on Horticulture and Plantation Crops for the Eleventh Five Year Plan has projected the total requirement of planting materials of fruits, coconut, cashew, black paper, tree spices, areca-nut etc. as 2000 million by the year 2012 at a modest growth rate of 4% per annum. In the segment of fruit crops alone, the projected demand for the planting material was 7,145,851 by the year 2007-08; which may increase to 8,359,632 by the year 2011-12 (Mishra, 2009).

3. According to Ravishankar and Ramasubramanian (2004), the mangrove nursery which was raised jointly by Andhra Pradesh Forest Department and MSSRF for restoring about 1,500 ha has the capacity to raise 1, 20,000 saplings per year. They suggested that polythene bags of 5"x 8" should be used to raise the mangrove saplings in the nursery.

4. Sengupta and Desa (2001) reported that a moderate mangrove nursery in Goa, can raise approximately 40, 000 to 50, 000 seedlings at a time. Though all these nurseries use polybags of dimension 8" x 4" with holes at the base.

5. For greening Sikkim, the target fixed by Government of Sikkim is to raise 1 crore Quality Planting Material, QPM seedlings beginning from the year 2009-2010 (Lachumpa, 2009).

The current prices of different black polybags (different sizes) are provided below in the Table 2.

Table 2: Prices of polybags of different sizes in Kolkata in December 2010

Dimension of polybag (Length x Flat width)	Price (in Rs.)/ bag
7" x 6"	0.46
8" x 6.75"	0.59
12.5" x 12.5"	2.09

References

Department of Environment, Govt. of NCT of Delhi, May, 2010,
http://www.delhi.gov.in/wps/wcm/connect/environment/Environment/Default/Achievements

Green India Mission to double afforestation efforts by 2020. 26th May, 2010. *The Hindu*, New Delhi.

Lachumpa, C., 2009. *The Status of Forest Nurseries and Future Action Plan*, Forests, Environment and Wildlife Managenment Department, Government of Sikkim, 2009-2010.

Mathur, M., 2009. *Agrotextiles: Need of the Hour*-Editor's page, The Synthetic and Art Silk Mills' Research Association, Mumbai.

Mishra, P.K., Secretary, Ministry of Agriculture, Department of Agriculture & Cooperation, Government of India, July, 2008.

Mohanan, C., Sharma, J.K., 2005. Improvement of seedling production system in forestry sector and its impact on seedling health, *Working papers of the Finnish Forest Research Institute 11*, http://www.metla.fi/julkaisut/workingpapers/2005/mwp011.htm, pp. 77-82.

Multipurpose Tree Species for Agroforestry in India, Editors N. G. Hegde and J. N. Daniel, Proceedings of the National Workshop, 6-9 April 1994, Pune, India

Pramanick, P.K., Director (Horticulture) and Mission Director, State Horticulture Mission, Directorate of Food Processing Industries and Horticulture, Department of Food Processing Industries and Horticulture, Govt. of West Bengal, 2009.

Ravishankar, T. and Ramasubramanian, R. 2004. Manual on Mangrove Nursery Raising Techniques, published by M.S. Swaminathan Research Foundation; Chennai, India.

Report on TECHNOTEX-2009. *Providing better, secure and sustainable life*. Workshop-cum-Exhibition on "Strengthening Government-Industry-Consumer Partnership in Agrotech and Oekotech, September 18, 2009, Ministry of Textiles & FICCI, New Delhi.

Sengupta, R., Desa, E., 2001. *The Indian Ocean: a perspective*, A.A. Balkema publication, Vol.2.

6. DETAILED REPORT ON R&D

6.1. Methodology of R&D Activities

The following methodological steps were taken to fulfill the objectives of the project:

a. Development of a suitable jute braiding machinery along with its winding unit and its further necessary modifications
b. Development of 'jute tape' of suitable dimension from inferior quality jute batch to be used as 'axial material' for tri-axial braiding
c. Development of jute braided nursery sapling sleeves utilizing jute yarns/ jute roves/ jute tapes as 'axial material' bound by standard jute yarns as 'braiding yarns' and their vis-à-vis cost-effectiveness and physical property study.
d. Preparation of jute braided nursery sapling bags from the developed sleeves adopting suitable techniques
e. Assessment of performance variability of the developed jute nursery sapling bags in terms of seedling care. The assessment is based on seedling morphological traits and effect of degraded jute on nutrient level of soil.
f. Establishment of the developed product's efficacy in respect of providing sapling care through actual field trial at horticulture nursery. The assessment is based on seedling morphological traits and soil loss from the sapling bag.
g. Preparation of jute braided vertical drain sample (a typical geotextile) employing coarse jute yarns and coir yarns

6.2. R&D Activities with their Results & Outcomes

6.2.1. Machinery modification & development

6.2.1.1. Main machinery development

Jute braided seedling/ sapling bags are expected to be the cost-effective and eco-friendly substitute of polybags. To minimize the soil loss during handling and transportation, the cover of these tubular fabrics should be as high as possible.

The maximum dimension of the product aimed at is 9" (length) x 6" (flat width), while the minimum length x flat width can be as low as 3.5" x 3.5".

Accordingly, it was decided to fabricate a new braiding machine suitable for producing the intended products having higher flexibility in changing machine parameters and other desirable features for wider research scope along with suitable yarn winding unit to meet the project objectives. After an in-depth analysis of the requirement of the desired product, it was decided to fabricate a braiding machine with the following specifications.

Some important features of the braiding machine with control panel (Fig. 6.2.2 - 6.2.6):

- A 48-spindle machine capable of braiding continuous tubes of maximum flat width of 6 inch- narrower tubes can easily be produced

- Independently controllable fabric take-up speed and braiding speed within a specified range with the help of Programmable Logic Control (PLC) system installed within the control panel. The ranges are:
  - Fabric take-up speed: 365 – 3800 mm/min
  - Braiding speed (angular velocity of yarn carrier): 0.50 – 6.38 r.p.m.
- Provision for inserting maximum 24 axial threads for axial rigidity and body to the tubular cloth
- Heavy-duty spindle (Fig. 6.2.3):
  - Spring along with four small pulleys to control the yarn tension in better way
  - Changeable tension-control springs for braiding different counts of yarn
  - Dimension of bobbin: Outer diameter – 72 mm, Inner diameter – 25 mm, Height – 285 mm. Such big bobbins can take 195 m of a strand consisting of 10 yarns each of count 8 lb/ spyndle.

Some important features of the winding unit with control panel (Fig. 6.2.1):

- Capable of winding up to a maximum of 12 yarns in parallel mode
- Automatic Stop motion present
- Yarn winding speed can be varied up to 100 m/min approximately
- Number of coils per double traverse can be varied
- Length of yarn per bobbin can be set
- Displays on the panel are:
- Length of yarn wound (m)
- Yarn winding speed (m/ min.)

Fig. 6.2.1. Winding unit for the new jute braiding machine

Fig. 6.2.2. New jute braiding machine

Fig. 6.2.3. Yarn package carrier/ spindle

Fig. 6.2.4. Fabric take-up system

Fig.6.2.5. Control panel for jute braiding machine

Fig. 6.2.6. Braiding on mandrel

6.2.1.2. Fabrication of yarn tensioners for axial yarns

The tensioners provided by the fabricator (Fig. 6.2.7) in the newly fabricated braiding machine have the following limitations:

- Inadequate to impart required tension to the axial yarns
- It was not also possible to change the tension as per requirement over a wide range
- Dimension and roughness of the system won't allow jute tape or very coarse jute yarns (e.g. jute roving yarn) to pass through smoothly.

Consequently, 24 sets of multiple post mild-steel tensioners (Fig. 6.2.8) employing capstan principle were fabricated and mounted below the base-table of the braiding machine, each set having the following dimensions:

a. Height: 250 mm
b. Width: 25 mm
c. Side supports: plate of width 20 mm of 250 mm length and 4 mm thickness

d. Number of posts: 7 (each step made of smooth rod of 6 mm diameter)
e. Centre-to-centre distance between two posts: 32 mm

Fig. 6.2.7. Existing tensioners for axial materials on the braiding machine

Fig. 6.2.8. Fabricated tensioners for axial materials mounted on the braiding machine

6.2.1.3. Fabrication of flexible guides for axial materials

The fabricator provided 12 rigid continuous pipe guides and 12 flexible guides (Fig. 5.2.9) for the axial yarns. But, on exploration, the rigid continuous pipe guides were found unsuitable for coarse soft spun jute roves/ jute tape yarns (made from jute 3rd drawing sliver). Hence, another 12 flexible guides were fabricated following the design same provided by the fabricator (Fig. 6.2.10 - 6.2.12).

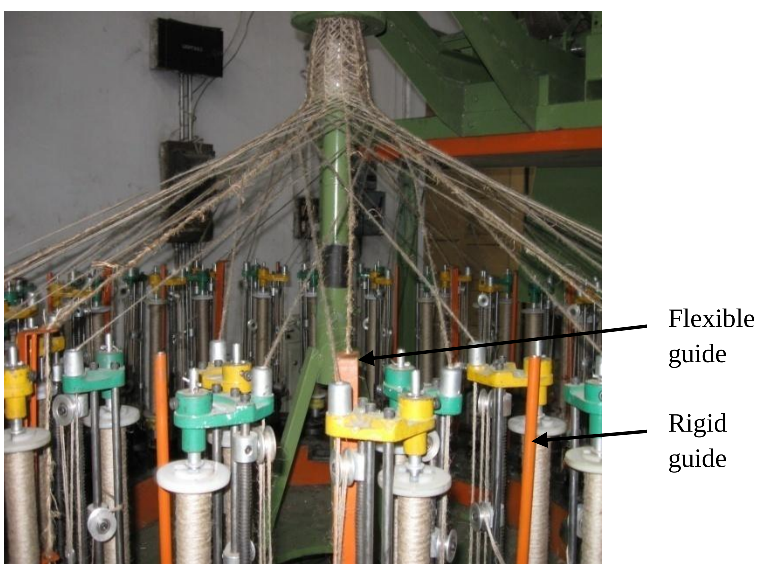


Fig. 6.2.9. Braiding machine mounted with rigid and flexible guides for axial materials

Fig. 6.2.10. Flexible guide for axial material

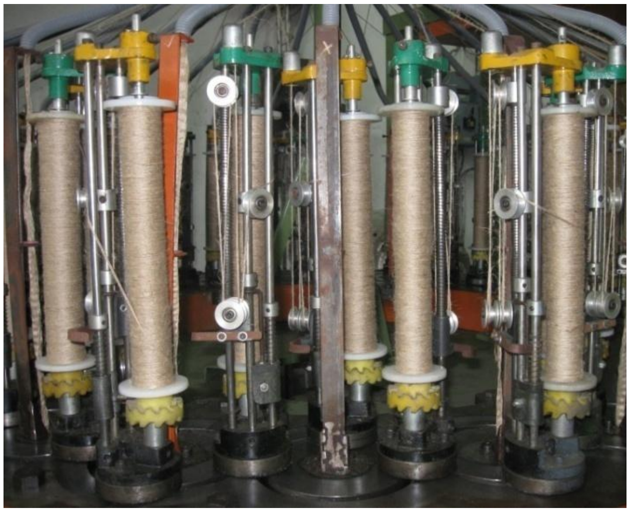


Fig. 6.2.11. Braiding machine mounted with all 24 flexible guides for axial materials

Fig. 6.2.12. Appearance of braided sleeve during braiding with 24 flxible guides for axial materials

Fig. 6.2.13 Present actual view of the jute braiding machine (after modification)

7. PRODUCT DEVELOPMENT

To engineer the desired product, i.e., jute braided sapling bag, structure – property relationship of braided sleeve samples was studied by varying raw materials of braiding and axial yarns/ materials in three different consecutive approaches which are described in the following sections below.

7.1. Preliminary Experiments

Initially, preparation of jute braided sapling sleeves employing different jute yarns having count from 8 lb/ spyndle to 32 lb/spyndle (used as both axial and braiding yarns) revealed that increase in yarn count/ or sleeve mass is much faster than the increase in yarn diameter/ or fabric cover and hence could not be a cost-effective solution to the present problem (Table 3 and Fig. 7.1.1 below).

Table 3: Interdependence between Yarn Count, Fabric Areal Density and Fabric Cover

Yarn count (lb/spyndle)	Areal density of jute braided sleeve (g/ m^2)	Diameter of yarn (mm)			Fabric cover (calculated)
		Average	C.V.%	Range	
6	293.7	0.78	20.26	0.49-1.09	0.214
14	690.0	1.04	16.99	0.69-1.53	-
24	740.0	1.49	17.87	1.07-2.03	0.377
28	880.5	1.59	16.35	1.18-2.07	0.495

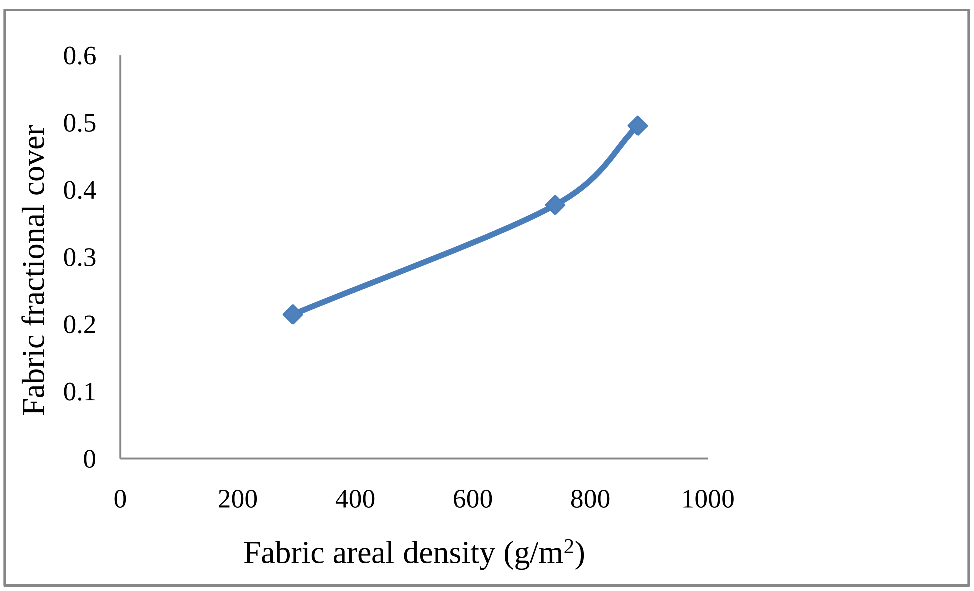


Figure 7.1.1. Interdependence between Fabric Cover & Fabric Areal Density

A methodology was conceptualized employing soft-spun more hairy jute rove yarn in combination with finer jute yarn of suitable count for improving the cloth cover (or porosity) of the braided sleeve without raising the areal density appreciably and making the product cost-effective. In this approach, soft-spun jute rove yarns (125 or 140 lb/ spyndle) which are extremely coarse and hairy and hence cheaper than normal jute yarns were supposed to provide the desired cover to the fabric while being employed as axial yarns during braiding and finer count costly jute yarn (8 lb/ spyndle) would be used as braiding yarns just to bind those coarse axial threads. To this end, some samples were prepared employing combinations of fine and coarse jute yarns changing related machine parameters, like, machine RPM and take-up speed. The samples produced were very rugged in look having poor cover but with areal density and thickness higher than desirable. A typical sample is shown in Fig. 7.1.2 and its particulars in Table 4 below.

Table 4: Thicknesses of jute braided sleeves

Sample No.	Sample description	Thickness of sleeve (mm)	Areal density (g/m^2)
1.	Braiding yarn: 4, 8 lb/ spyndle jute yarn per spindle Axial material: 12 Jute roves	Avg.= 5.30 C.V.%= 6.01	1251.00
2.	Braiding yarn: 2, 8 lb/ spyndle jute yarn per spindle Axial material: 24 Jute tapes	Avg.= 3.41 C.V.%= 8.83	714.03

Fig. 7.1.2. Braided jute sleeve combining 12 jute roves as axial material and four 8 lb/ spyndle jute yarns in each yarn carrier

Fig. 7.1.3. Braided Jute sleeve combining 24 jute tape as axial material and two 8 lb/ spyndle jute yarns in each yarn carrier

To circumvent the problem of combining high cover and low mass in the product, it was thought prudent to explore the possibility of employing jute tape (instead of jute yarn) to provide the main body of the fabric. These tapes were to be held in position by a minimum number of jute braiding yarns. This concept necessitates development of jute tape from slivers, whereby these tapes should be as thin and as wide as possible while exhibiting a strength that should be sufficient to withstand the strains of braiding.

7.2. Development of Jute Tape

This tape is intended to be produced from jute sliver. This would reduce the cost of the product as cost of spinning would be saved. Such a sliver would be impregnated/ treated with suitable adhesive paste (e.g. starch/ TKP/ or any other) at Padding Mangle where it would be flattened due to squeezing at roller-nip. This flattened wet tape would be passed through a drying zone (contact drying/ hot air drying) and subsequently dried tape would be wound over a suitable package. Multiple sliver treatment is essential to make the process economically viable.

To this end, suitable machinery has to be designed and fabricated for preparation of jute tapes from jute slivers. This system should consist of a proper flattening system combined with an adhesive paste application unit, followed by a drying unit and a winding unit to build package/s from the dried up jute tape/s. The winding unit should be able to build packages suitable for side-ways withdrawal as this type of package would be appropriate to be mounted under the braiding machine base-plate.

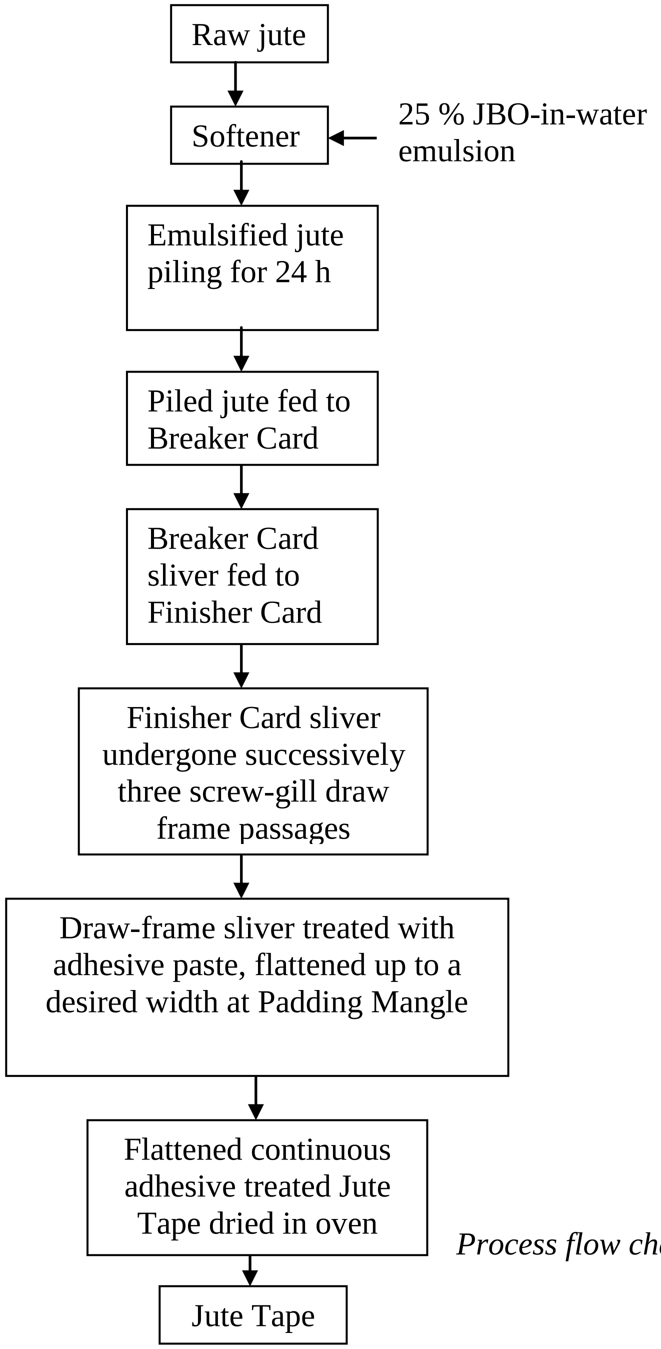
Presently, in IJIRA pilot plant, such tapes were produced from raw jute. It was tried to produce lightest possible jute tape. At this stage, single sliver treatment has been carried out using Revive instant starch as adhesive (add-on %: 4). The wet jute tapes coming out of the Padding Mangle is collected manually on a polythene sheet kept on the ground and thereafter dried in an electrical oven. The dried jute tape of 25 m (approximately) length was manually wound into 'balls' to feed the braiding machine with the axial tape yarns below the machine base-table. The process flow chart is provided below.

Some relevant process details are listed in Table 5. Table 6 shows dimensional properties of corresponding braided samples wherein the number of yarns in strand as also the type and number of axial yarns were varied.

Table 5: Preparation of jute tapes

J.B.O. percentage: 2% of raw jute; Emulsion application: 25%; Duration of piling: 24 h

Width of jute tape (mm)	Jute sliver count (lb/ spyndle)	Starting material	B/C feed (g/m)	F/C doubling	1st drg. Draft & doubling	2nd drg. Draft & doubling	3rd drg. Draft & doubling	Adhesive paste conc. (g/l)
20	134.92	Raw jute	1500	11	2, 3.7	3, 6.3	2, 8.5	40
10	73.82	Raw jute	1100	10	2, 4.5	3, 6.5	2, 9.5	40
7	67 & 61	Raw jute	900	9	2, 4.5	3, 6.5	2, 9.5	40



Process flow chart of Jute Tape

It was found that jute tape wider than 10-12 mm would be folded inside during passing through the hole of braiding machine base-plate as the latter is of diameter 11 mm approximately. This also collapses the tape structure partially. Hence, this machine particular has imposed a restriction to go much beyond this width for the jute tapes.

A new problem arose while braiding with jute tape as axial material. The jute tapes got false-twisted due to oppositely moving/ crossing braiding threads before getting embedded into the braided structure and thereby the tape-like structure collapsed into elliptical/ rounded cross-section. As a result, the expected fabric cover was not achieved. To mitigate the problem, two different approaches were explored as discussed below.

a) The jute braided samples were treated as follows,

The jute braided samples were submerged under water at room temperature for 1 h. Subsequently, the wet sample was allowed to drip for 10 minutes before being passed through the padding mangle twice slowly but keeping the pressure as high as possible. The whole process was carried out once and twice for two sets of samples. This was aimed at achieving the maximum flattening of the jute tape yarns inside the braided fabric. The related results are provided in Table 4 and 5. This process reduced the sample thickness considerably but the samples shrunk width-wise appreciably and the areal density went up by about 20%. Clearly such a process, in addition to raising the product cost, does not serve the purpose.

b) Using flexible plastic pipe-guides for axial tapes

Twenty-four flexible plastic pipe guides were employed to guide the jute tapes right from its exit from the flexible guide up to the braiding point on or near the mandrel (Fig.7.2.1). This approach was successful to prevent the axial yarns from getting false-twisted and in this way effective cover provided by the tape material was improved (Fig. 7.1.3).

Dimensional properties of three different types of braided sleeves and the resultant sapling bags are listed in Table 9.

7.3. Sapling bag preparation steps from the jute braided sleeve

1. The continuous braided sleeve has to be cut to a length slightly (by 1" approx.) higher than twice the length of the intended bag.
2. Half the length of the sleeve is then pulled over a hollow PVC pipe of suitable diameter.
3. The other half of the sleeve protruding outside the tube is pushed into the tube by a suitable wooden mallet.
4. In this state, the folded (doubled) sleeve-piece is to be removed out of the pipe by pulling carefully.
5. The frayed double-end of the piece is to be tied securely with a strong enough jute thread leaving the frayed part as small as possible.
6. The piece is to be put on the PVC pipe again keeping folded end in contact with the pipe mouth.
7. Now, with the help of the wooden rod the tied end is to be pushed inside the PVC pipe and by light hammering with this rod the ultimate shape of the bag is imparted.

In Fig. 7.3.1, the actual photograph of one seedling planted in jute braided sapling bag of dimension (9" x 5") prepared following the above procedure is shown. This process fabricating sapling bag from the braided sleeve results in high cover, high radial rigidity and a stable base of the product that permits easy filling with soil and secure storage and transportation.

Fig. 7.2.1. Braiding with 24 jute axial tape utilizing 24 flexible plastic pipes as their guides

Fig. 7.3.1. Seedling planted jute braided sapling bag

Table 6: Jute Braided Sleeve sample analysis

Count of jute finisher sliver used for tape preparation = 134.9 lb/ spyndle

Sample No.	Number of yarns/ spindle	Number of axial jute tape/ roving yarn	Flat Width (cm)	Areal density of braided sleeve (g/ m^2)
1.	2	21(tape)	13.17	961.78
2.	8	18(tape)	14.00	1587.00
3.	4	12(rove)	12.00	1251.00

Table 7: Analysis of jute braided sleeves after combined water-submersion and pressure treatment

Sample Type	Number of yarns/ spindle	Number of axial jute tapes	Sample dimension (cm)		Sample mass (g)	Areal density of braided sleeve (g/ m^2)
			Length	Flat Width		
1-Control	2	21	60	13.17	76	961.78
1-once water + Pressure treatment	2	21	100	10.78	128	1187.38
1- twice water + Pressure treatment	2	21	100	10.22	116	1135.03

Table 8: Widths and thicknesses of the Jute Tapes embedded in the samples of Table 7

Sample Type	Width (cm)	Thickness (mm)
1-Control	1.04	1.99
1-once water + Pressure treatment	0.88	1.94
1- twice water + Pressure treatment	0.86	1.58

Table 9: Braided sleeve samples prepared with PVC pipe guides for axial jute tapes

Number of yarns/ spindle = 2, Count of braiding yarn= 8 lb/ spyndle, No. of axial jute tapes = 24

Count of jute tape (lb/spyndle)	Width of jute tape (mm)	Avg. width of jute tape embedded within fabric (mm)	Avg. flat width of braided sleeve (cm)	Areal density of braided sleeve (g/ m^2)
134.92	20	14.25	12.75	1134.38
73.82	10	9.00	12.46	763.07
61.00	7	6.70	11.00	714.03

8. FIELD TRIALS

8.1. Approach

Four experimental sets were designed to assess the efficacy of the newly developed jute braided nursery sapling bags in taking care of nursery saplings during the stay period in nursery and their role even after transplantation in field. Those are described in section 8.2 – 8.5. Performance evaluation of this agrotextile product was carried out based upon some judiciously selected morphological traits described in the section 4.3.

8.2.Preliminary Experiments

8.2.1. Study on seedling morphological traits

To determine statistically the performance variability of the sapling bags developed in terms of seedling care, a preliminary experimentation plan was designed and accordingly carried out in IJIRA in November 2011 (Fig. 8.2.1.1). The detail of this is provided below.

- Type of saplings chosen:
  a) White Marigold-last for 3 months
  b) Kamini (Orange Jasmine) – perennial plant
- Type of jute braided sapling bag employed:
  - Mass: 40g
  - Dimension: 22 cm (length) x 13 cm (flat width)
  - Construction: 2/ 2 regular tri-axial braided structure
    Braiding yarns: 48 x 2, 8 lb/ spyndle jute yarns
    Axial materials: 24 jute tapes
- Start date: 03.11.2011
- Performance evaluation based on:
  - Seedling morphological traits – *Stem base diameter (SBD) & Stem height (SH) from a reference level* with time

Fig. 8.2.1.1. Preliminary trial at IJIRA: Seedling care with Jute braided sapling bags developed

Experimental results are shown in Table 10 and Table 11.

Table 10: Stem Base Diameter and Stem Height Data for White Marigold Saplings

Sapling No.	Stem Base diameter (mm)			% increase in diameter in 1 month	Stem height (mm)		% increase in height in 14 days
	On 3.11.11	On 14.11.11	On 1.12.11		On 14.11.11	On 28.11.11	
M1	2.36	2.67	3.91	65.68	73	127	73.91
M2	2.59	2.67	4.47	72.59	98	149	51.61
M3	2.44	2.46	3.71	52.05	70	121	72.72

- Calculation for number of repeat tests required

Increase in *stem base diameter* of the white Marigold saplings in 1 month:

Average: 1.57 mm, Sample s.d. = 0.305, C.V. = 19.49 %

Considering 95 % confidence limit,

Maximum error = [{(1.96 x sample s.d.)/ √ (2 x No. of repeat tests)}/ sample s.d.] x 100

= 80.02 %

If maximum error has to be reduced to 10 % (say):

Number of repeat tests = $\{(1.96 \times C.V.)/ \text{Maximum error}\}^2$

= 14.5 ≈ 15

Increase in *stem height* of the white Marigold saplings in 14 days:

Average: 52 mm, Sample s.d. = 1.732, C.V. = 3.33 %

Similarly as above- mentioned calculation, if maximum error has to be reduced to 5 %,

Number of repeat tests= 1.7 ≈ 2

Actual growth of a typical White Marigold sapling planted in developed jute braided sapling bag is shown in Fig. 8.2.1.2 - 8.2.1.4.

Fig. 8.2.1.2. View of a Marigold sapling planted in jute braided sapling bag on 14.11.2011

Fig. 8.2.1.3 View of the same Marigold sapling on 28.11.2011

Fig. 8.2.1.4. View of the same Marigold sapling on 19.12.2011

Table 11: Stem Base Diameter Data for Kamini Saplings

Sapling No.	Stem Base diameter (mm)		% increase in diameter in 17 days
	On 14.11.11	On 1.12.11	
OJ1	5.30	5.44	2.64(rejected-too low value)
OJ2	4.80	5.20	8.33(rejected-too high value)
OJ3	4.52	4.84	7.08
OJ4	4.88	5.08	4.10
OJ5	4.50	4.78	5.86
OJ6	5.52	5.80	5.86

- Calculation for number of repeat tests required

Increase in *stem base diameter* of the Kamini saplings in 17 days:

Average: 0.27 mm, Sample s.d. = 0.0503, C.V. = 18.64 %

Considering 95 % confidence limit,

Maximum error = [{(1.96 x sample s.d.)/ √ (2 x No. of repeat tests)}/ sample s.d.] x 100

$= 69.58\ \%$

If maximum error has to be reduced to 10 % (say):

Number of repeat tests = $\{(1.96 \times C.V.)/ \text{Maximum error}\}^2$

$= 13.35 \approx 14.$

During the above experimentation it was observed that soil loss from the planted jute sapling bags became negligible within 5-7 days.

8.2.2. Soil-analysis experimentation

To investigate the effect of biodegraded jute sapling bag on the nutrient level of soil, a soil-analysis exercise was carried out before and after transplantation in field. To this end, soil-analysis experimentation was carried out on the control soil samples and treated soil samples (soil with degraded jute) after elapsing of a predetermined time after transplantation of the saplings along with the jute braided sapling bags already studied under preliminary experimentation activities (Ref. section 8.2.1). The experimental plan is provided below (Fig. 8.2.2.1).

Soil types:

a) Control soil: soil samples collected from similar pits as those made for transplantation of saplings along with the jute braided sapling bags but were located at a distance of 1.5 ft away from the planted ones
b) Treated soil: soil samples collected from the three pits planted with saplings along with the jute braided sapling bags

Soil Test particulars:

a) Nitrogen content
b) Phosphorous (P_2O_5) content
c) Potassium (K_2O)content
d) Organic carbon (%)

Test schedule:

a) Soil test after 55 days of transplantation

Start date: 19th December 2011.

(a)

Fig. 8.2.2.1. Three White Marigold saplings along with jute braided sapling bags (a) during and (b) just after planting in field (at IJIRA premises) soil analysis experimentation

(b)

Table 12: Soil analysis result

Sample Type	pH	Organic carbon (%)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
Control soil	7.67	0.78	384.0	66.3	163.8
Treated soil	7.53	**1.48**	361.0	**118.5**	**371.6**

From Table 12, it is clear that bio-degraded jute has enhanced soil-nutrient level by enriching the soil considerably with organic carbon, phosphorus and potassium.

8.2.3 Root growth study

This study was carried out on the Kamini saplings along with the jute braided sapling bags studied under preliminary experimentation activities (Ref. section 8.2.1). The experimental plan is provided below.

- Two Kamini Saplings planted within jute sapling bags were subjected to root growth study immediately on 19th December 2011.
- Three Kamini saplings along with the jute sapling bags were planted in field immediately on 19th December 2011.
- Three Kamini Saplings were allowed to continue growing in the jute sapling bags instead of being planted within the field.

Quantitative estimation of the following morphological traits of the saplings was carried out:

a) Root volume (in cm^3)
b) Root length (in cm)

Root growth data was collected at an interval of 30 days for the saplings planted in soil as also for those continuing to grow within the jute sapling bags. The results are provided in Table 13.

Additionally, a qualitative estimation was carried out by taking photographs of the root systems of the three saplings encased within jute sapling bags (if at all persist) by carefully excavating from soil.

The above-mentioned exercise was carried out to assess the performance of the jute braided sapling bags in nursery and their role even after transplantation in field.

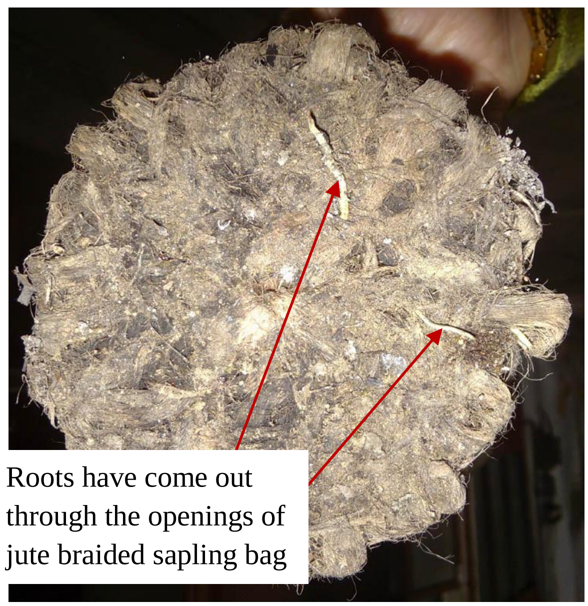


Fig. 8.2.3.1. Actual view jute braided sapling bag bottom planted with Kamini sapling on 19.12.2011

Fig. 8.2.3.2. Actual view of the root network with soil of the same sapling just after removal of the jute braided sapling bag on 19.12.2011

Root growth measurement process is shown in Fig. 8.2.3.3 – 8.2.3.8.

Fig.8.2.3.3 Jute braided sapling being cut open

Fig. 8.2.3.4 Actual view of the root system with soil inside bag

Fig. 8.2.3.5. Root system along with soil mass dipped in water for loosening

Fig. 8.2.3.6. Loosened soil being washed out from root network under running tap water

Fig. 8.2.3.7. Well-grown root network of Kamini sapling planted in jute sapling bag

Fig. 8.2.3.8. Root volume measurement using calibrated volumetric flask

Fig. 8.2.3.9. Roots of Kamini sapling grow through jute braided sapling bag and penetrates within soil

Fig. 8.2.3.10 Root growth of Kamini sapling through jute braided sapling bag inside soil in 30 days - (exhumed on 19.01.2012)

Fig. 8.2.3.11 Actual view of Kamini seedling planted in Jute Braided Sapling bag after six months from plantation

Table 13. Root growth data of Kamini saplings grown in jute braided sapling bags

Average root length (cm)			Average root volume (cm^3)		
On 19.12.2011	On 19.01.2012		On 19.12.2011	On 19.01.2012	
	Saplings in bag kept over ground	Saplings planted in soil with bag		Saplings in bag kept over ground	Saplings planted in soil with bag
10.25	13	14	10.0	11	11

From Table 13, the followings findings were made:

(i) In one month, average root length of Kamini saplings planted in jute braided sapling bag has increased substantially in both the cases - while those were kept over ground (26.83 %) and those planted in soil along with the bag (36.58 %)

(ii) During the same time, increase in average root volume is 10 % only.

It can be concluded from the above findings and Fig. 8.2.3.3 – 8.2.3.10 that the jute braided sapling bags allows healthy root network growth and unrestricted emergence of the roots through its openings.

8.3. Field Trials at Horticulture Nurseries

8.3.1. Trial at Horticulture Nursery 1: Comparative performance evaluation of the jute braided nursery sapling bag vis-á-vis nursery sapling polybags

The Agri-Horticulture Society of India, Alipur, Kolkata was selected as the suitable place for the first horticultural nursery field trial for comparative performance evaluation of the jute braided nursery sapling bags vis-á-vis nursery sapling polybags of similar dimension. The plan of work for field trial is provided below.

The performance evaluation study was carried out on the basis of following seedling morphological traits:

- Stem base diameter (in mm)
- Stem height from a reference level (in mm)
- Ratio of height to stem diameter (provides information about the seedling's sturdiness)

Additionally, after every 2/or 3-day soil-loss from the planted sapling bags was recorded during initial period of the trial until the loss becomes negligible. During this period the experimental sapling bags planted with saplings was kept on plastic trays to help in collection of soil coming out of those bags due to watering of the saplings.

- Type of nursery sapling bags:
    - Jute braided sapling bag : 15
    - Commercial sapling polybag : 15

Jute braided sapling bag : a) Braiding yarns: 48 x 2, 8 lb/ spyndle jute yarns
b) Axial materials: 24 jute tapes

- Type of seedling chosen: Sunflower (*Helianthus annuus* L.) seedlings
- Number of repeat tests carried out (based on preliminary experiments): 15
- Duration: 2 months – seedling morphological data would be collected at an interval of 15 days

Analysis of data from the above experimentations was useful in understanding the role of the jute braided sapling bag in-depth and establish quantitatively the level of efficacy of the newly developed product during its application in nurseries.

Field trial start date: 25th January, 2012

Fig. 8.3.1 Actual view of field trial on 15.02.2012

Fig. 8.3.2 Actual view of field trial on 01.03.2012

In Fig. 8.3.1-8.3.2, the growth of sunflower saplings planted in jute braided sapling bags and polybags are shown during a period of 15-days.

Table 14. Soil-loss data

Soil collected on	Soil loss from 15 planted jute braided sapling bags (g)	Soil loss per jute braided sapling bag (g)	Soil loss from 15 planted polybags (g)	Soil loss per polybag (g)
27th Jan. 2012	16.1	1.07 (in 2 days)	13.9	0.93 (in 2 days)
2nd Feb. 2012	5.3	0.35 (in 6 days)	14.5	0.97 (in 6 days)

From Table 14, it is clear that soil-loss from jute braided sapling bag is comparable or slightly higher than polybag initially, but it rapidly diminishes to a negligible level within 6 days. On the contrary, soil-loss from polybag reduces very slowly with time and is three times higher than its jute counterpart even after 6 days. Hence, *performance of jute braided bags is far better than sapling polybags with respect to soil-loss* during the stay-period at nursey.

Table 15. Stem base diameter (SBD) results

Type of sapling bag used	Average SBD of saplings (in mm) on				Average Difference in SBD		
	02.02.2012 (a)	15.02.2012 (b)	01.03.2012 (c)	09.03.2012 (d)	(b-a) mm	(c-a) mm	(d-a) mm
Jute braided bag	3.726 (13.71%)	5.166 (13.92%)	7.634 (12.25%)	7.958 (12.61%)	1.439 (36.34%)	3.907 (18.76%)	**4.231 (18.22%)**
Polybag	3.839 (16.09%)	5.617 (14.37%)	7.403 (13.82 %)	7.878 (15.88%)	1.778 (38.32%)	3.564 (26.41%)	**4.038 (25.71%)**

N.B. C.V. % values are provided within parentheses

Table 16. Stem height (SH) results

Type of sapling bag used	Average SH of saplings (in cm)				Average Difference in SH		
	On 02.02.2012 (a)	On 15.02.2012 (b)	On 01.03.2012 (c)	On 09.03.2012 (d)	(b-a) cm	(c-a) cm	(d-a) cm
Jute braided bags	7.192 (14.31%)	13.146 (22.07%)	34.231 (18.05%)	49.577 (19.45%)	5.954 (38.23%)	27.038 (20.98%)	**42.385 (21.83%)**
Polybags	8.169 (16.55%)	16.107 (22.84%)	37.123 (24.34%)	53.615 (25.59%)	7.938 (33.65%)	28.953 (27.74%)	**45.446 (28.10%)**

N.B. C.V. % values are provided within parentheses

Growth data for stem base diameter (SBD) and stem height (SH) are tabulated in Table 15 and 16. These results reveal that SBD growth is marginally higher for saplings planted in jute braided sapling bags than those planted in polybags while reverse is true with respect to SH growth. But statistical analysis reveals that both of these differences are not significant at 95 % and 99 % level of confidence. Hence, it can be concluded that growth of sunflower seedlings with respect to the morphological traits, viz., SBD and SH are similar or comparable in both type of sapling bags under experimentation.

Fig. 8.3.3 Root growth in jute braided bag

Fig. 8.3.4 Root growth in sapling polybag

In Fig. 8.3.3 and Fig. 8.3.4, it can be observed that emergence of a root network through the jute braided sapling bag while single root is able to come out through the hole punched in polybag. This is due to the fact that jute braided sapling bags are porous owing to its inherent structure. Consequently, air circulation inside the soil mass of those bags was good which results in healthy root network formation within jute braided sapling bags. On the contrary, porosity of polybags is almost zero. Hence, a few holes were made in those bags before soil-filling for facilitating emergence of the growing roots, water drainage and air circulation. In spite of making holes, air circulation was mostly restricted inside the polybags resulting in comparatively poor root network formation as those for jute bags. This was evident from emergence of fewer roots from some of those holes (**Appendix-i**).

8.3.2. Trial at Horticulture Nursery 2

The second horticulture nursery trial was conducted at Sahayog Hortica Pvt. Ltd., South 24-Parganas. Three types of jute braided nursery agrotextile products were used for their field performance assessment at the above-mentioned nursery.

1. Jute braided sapling bags (Length: 9”, Flat width: 5”)
2. Jute braided sleeve of flat width- 8 cm
3. Jute braided sleeve of flat width - 11 cm

The nursery employed the sapling bags for planting seedlings of Red Sandalwood and White Sandalwood. The related feedback report issued by the nursery is provided in **Appendix-ii**.

The nursery reported another potential use of the jute braided sleeves mentioned above, i.e., the ***covering fabric of ‘Moss-stick’*** for climbing plants having aerial roots in home gardens (**Appendix-ii**). At this point, it should be mentioned that ‘Moss-sticks’ are pre-fabricated supporting sticks for those creeper plants. The stick is prepared by wrapping a plastic pipe of diameter, 1” to 2” and length, 1 m to 2.5 m with the ***covering fabric/ sleeve*** encasing a thick layer of coir fibres in between.

9. PRODUCT/ PROCESS STANDARDIZATION

During the ongoing R&D activities of the project, the concept of jute tape as the main component of jute braided sapling sleeves has been evolved. At the initial stage, jute tapes were prepared one at a time from jute slivers (60 lb/ spyndle) employing laboratory padding mangle. Evidently, to make the process commercially viable, multiple jute tape production is essential. To achieve this, following activities were undertaken.

9.1. Manufacture of Multiple Jute Tapes

9.1.1. The concept for machine designing

For manufacturing multiple jute tapes of suitable dimension (i.e. width and thickness) and strength, a machine should be properly designed and fabricated accordingly which should contain the following parts:

a) Multiple sliver feed arrangement
b) Adhesive application and 2-roller single nip squeezing unit
c) Drying unit
d) Take-up unit
e) Winding unit

The feed unit should be capable of feeding maximum number of slivers which would be determined by the width of squeezing rollers and that of individual sliver. The adhesive application unit would be roller-nip feeding type to reduce the amount of applied adhesive and thereby amount of moisture to be evaporated for drying. The heart of the present problem is to design a proper and efficient drying system as production rate is directly related to it. A properly designed enclosed hot air based drying system may be useful for this purpose. Contact (conduction heating) drying has great chance to damage the very light weight jute tapes due to abrasive action and unwanted stretching at heating surfaces and radiation drying may not be cost-effective due to its extremely slow rate of drying and high capital cost.

In this context, it was decided to prepare a model system to demonstrate the basic principle of multiple jute tape manufacture by suitably modifying the laboratory padding mangle as it has already the roller squeezing arrangement. To this end, an endeavour was made to design and accordingly fabricate – (a) multiple sliver feed arrangement and (b) jute tape take-up device along with drying attachment followed by suitably mounting them on the padding mangle. Several actual photographs of the fabricated parts mounted/ attached with the laboratory padding mangle are shown in the following section.

Fig.9.1.1 Front-view of the multiple jute tape preparation model machine

Fig. 9.1.2 Multiple sliver feed arrangement

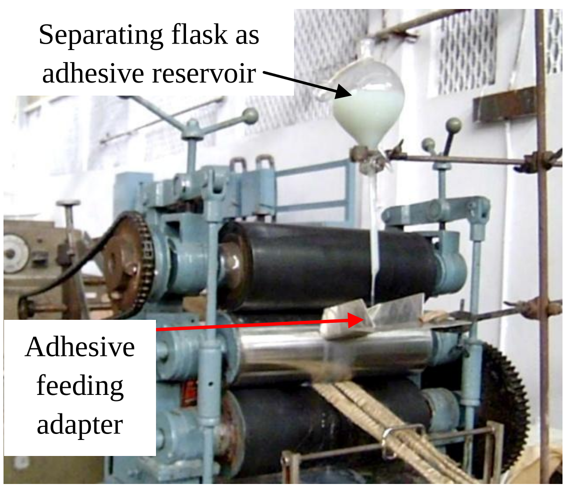


Fig. 9.1.3. Adhesive application arrangement

Fig. 9.1.4 Close-up view of adhesive application

Fig. 9.1.5 Multiple jute tapes coming out of squeezing roller nip and entering drying zone

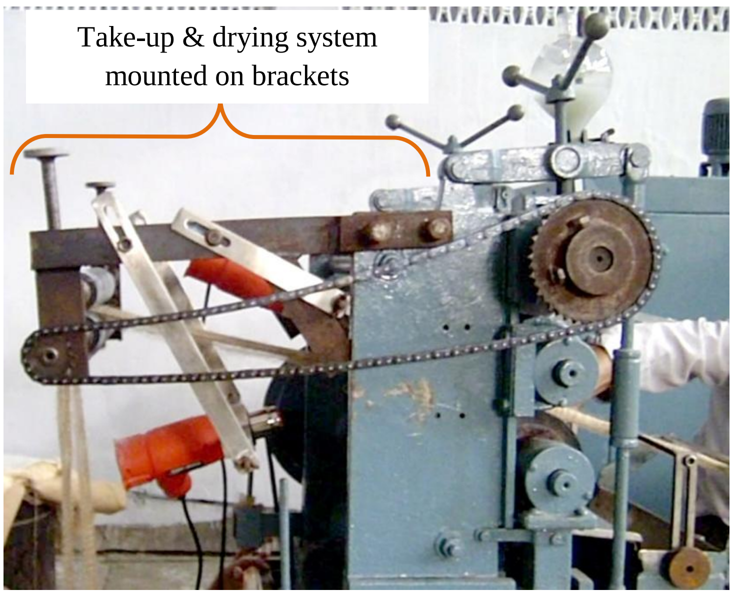


Fig.9.1.6. Side-view of the delivery side of the model machine

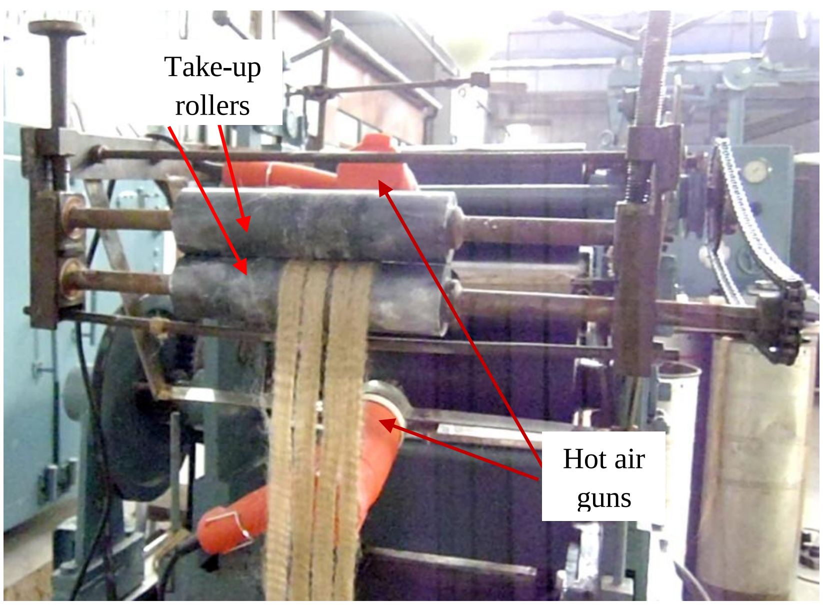


Fig. 9.1.7 Delivery end view showing position of two hot air guns with respect to emerging jute tapes along with take-up rollers

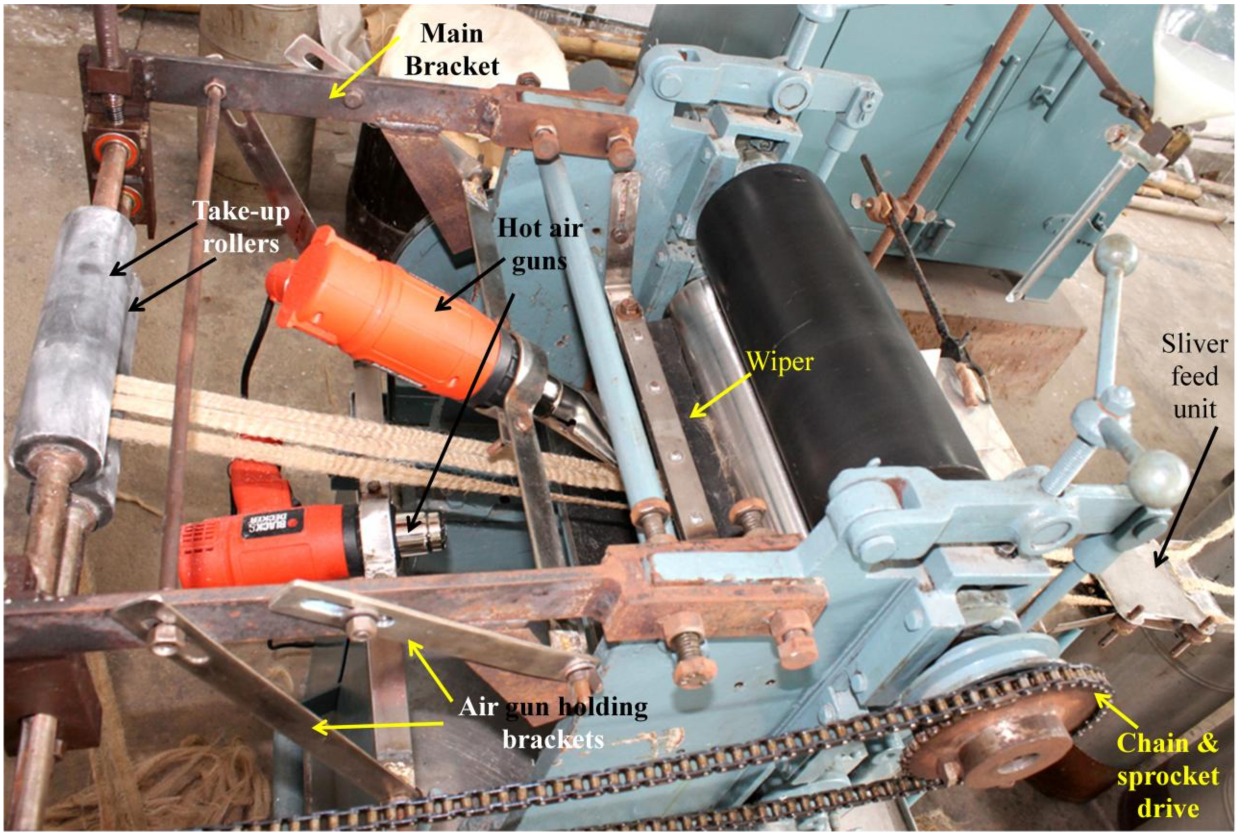


Fig. 9.1.8 Assembled view of the newly fabricated parts mounted on the padding mangle from top

9.1.2. Modification of the laboratory padding mangle - the Model System

The laboratory padding mangle has three vertically positioned rollers, having one middle steel roller in between two rubber coated rollers. The fabricated multiple-sliver feed system (Figs. 9.1.1-2) is mounted on an iron stand in front of this padding mangle and capable of feeding four slivers at a time. The feed system is basically composed of two trapezoidal steel plates having inner channels along the length. These channels are provided to guide the slivers for feeding those into the roller nip of the padding mangle in appropriate manner.

A separating flask/ funnel clamped on a laboratory iron stand is used as the reservoir for adhesive paste or suspension (Fig. 9.1.3). A metallic adapter is securely clamped at a lower height with the same stand as that of the flask (Figs. 9.1.3-4). With the aid of the adapter, the flow of the adhesive dripping out of the flask is directed towards surface periphery of the middle steel roller of the mangle at a suitable height from the nip of the bottom rubber roller and the mentioned steel roller. This is necessary to feed the incoming slivers with the adhesive paste right at the mentioned roller nip.

The fabricated take-up device and drying arrangement are mounted on the main MS bracket clamped securely with the padding mangle frame at the delivery side of the machine (Figs. 9.1.6-8). To avoid fibre lapping on the steel roller, a suitably fabricated wiper system is fitted along the machine width to scrap off the adhered fibres from the surface of the roller. The adhesive treated squeezed wet jute tapes after coming out of the nip of the steel roller and bottom rubber roller, firstly enter the drying zone (Fig. 9.1.5). The drying arrangement consists of two industrial hot air guns mounted in a particular fashion by means of two adjustable brackets fixed on the main bracket. Maximum air temperature of such a gun goes up to 500° C in enclosed system. These guns are so positioned that hot air stream encounters the emerging wet jute tapes from squeezing roller nip. The intention is to dry up the slivers to the maximum possible extent. As this place is not enclosed, heat energy loss is high. The almost dried jute tapes now are being drawn by the positively driven take-up roller arrangement from the heating zone and subsequently collected in a container (Fig. 9.1.7).

Some multiple jute tape samples were produced in this system. The particulars of the jute tapes are provided in Table 17 and 18. But, optimization of the production process and properties of these tapes is essential.

<u>Particulars of multiple jute sliver treatment (3rd drawing sliver)</u>
Adhesive used: Revive instant starch
Adhesive paste concentration = 30 g/l
Delivery speed of padding mangle = 6 m/ min.

Table 17. Particulars of Jute Tape produced

Mass of jute slivers taken (g) & MR %	Mass of bone-dry jute fibre (g)	Mass of wet jute sliver (g)	Wet pick up (%)	Mass of treated bone-dry jute sliver (g)	Add-on (%)
217.26, 12.36	193.36	425.4	90.93	198.02	2.41

Table 18. Test results of Mechanical & Physical Properties of the Jute Tape prepared

Width (mm)	14
Thickness (mm) under 2 kPa	0.72
Tensile strength (kg)	2.26 (CV%: 23.67)
Gauge length (cm)	30
Test speed (mm/ min.)	8 (time to break: 20±2)
Dimension of Jaws (cm)	Upper & Lower: L-3.5, W-2.5, T- 0.4

9.2. Fabrication of Feeder Assembly for Axial Material of Braiding Machine

It was decided to fabricate feeder arrangements for axial material which can accommodate large amount of jute tape in its bobbin so that machine stoppage time can be substantially reduced by reducing frequency of package change.

(a) **(b)**

Fig. 9.2.1 Fabricated feeder arrangement for axial material- (a) Empty bobbin, (b) Partially filled bobbin

In Fig. 9.2.1, newly fabricated feeder arrangement for axial materials is shown. This arrangement consists of one plastic (made of acrylic) bobbin/ package of suitable dimension provided in the following section and MS holding brackets. This arrangement is mounted below the base table of the braiding machine in a proper place so that the jute tape can be easily fed to the capstan type tensioners.

Feeding bobbin/ package dimensions and capacity:
Flange to flange distance = 11 cm
Maximum diameter of package (i.e. flange diameter) = 20 cm
Bobbin spindle diameter = 2 cm
Maximum volume of package = 3419 cm^3
Measured package density = 0.1 g/ cm^3
Mass of full package = 341.9 g
Count of jute tape = 50 lb/ spyndle
Jute tape content in full bobbin = 199.2 m

10. SAMPLE DEVELOPMENT OF JUTE-COIR BRAIDED VERTICAL DRAIN

An effort was also made to prepare sample of another jute-based braided technical textile product, namely, jute-coir braided vertical drain (a typical geotextile). This product would also be a tri-axially braided circular jute fabric encasing a number of coir yarns. To this end, the braiding machine was set to prepare the mentioned vertical drain samples at one go by carrying the following activities:

a) An assemblage of four coarse count jute yarns each of 28 lb/ spyndle was wound in parallel on the braiding bobbins (48 nos.).
b) Twenty-four double strand jute yarns, each of 28 lb/ spyndle were fed to the braiding zone as axial yarns. These axial yarns in combination with the braiding yarns would form the braided sheath part of the drain.
c) Eight coir yarns having fineness of 261.75 mpk (meter per kg) each were fed as a sheet to the braiding zone as core yarns.

During braiding, the sheath of jute forms continuously around the above-mentioned sheet of coir yarns and the whole assembly is pressed flat during passage in between the take-up rollers and subsequently collected in cans.

Fig. 16 Braided Vertical Drain: made of jute braided sheath and coir yarn core

Fig. 17 Jute-coir braided vertical drain rolls

Prepared samples of jute-coir braided vertical drains reveal the following properties upon testing as listed in Table 19.

The effect of lateral confining pressure on the thickness of the prepared drain sample and the drain sheath at various levels is depicted Fig.10.1. In the same plot area, the changes in thickness values at four different pressure levels for the whole drain and the drain sheath have been shown.

This would provide an idea about the actual condition of the drain under soil confinement after installation. It is to be kept in mind that the final thickness would be approximately equal to the sum of the thickness of individual coir yarns and six times the thickness of braiding jute yarns. Hence, depending on the constraints of the installing rig, the thickness of the drain can also be adjusted to the required value.

Table 19: Tested properties of jute braided vertical drain sample

Sl. No.	Drain properties	Test Method	Values
1.	Thickness in mm at 2 kPa pressure	ASTM D1777	11.63
2.	Width (mm)	-	100
3.	Mass of the drain in g/ linear meter	-	278.45
4.	Mass in g of braiding jute yarns/ linear meter	-	198.45
5.	Mass in g of axial jute yarns/ linear meter	-	49.44
6.	Mass in g of coir yarns/ linear meter	-	30.56
7.	AOS of braided sheath (O_{95}) in mm	ASTM D4751-99a	0.59
8.	Water Permeability ((l/m^2/s) at 50 mm water head	ASTM D4491-99a	23.07
9.	Permittivity (s^{-1}) at 50 mm water head	ASTM D4491-99a	0.45

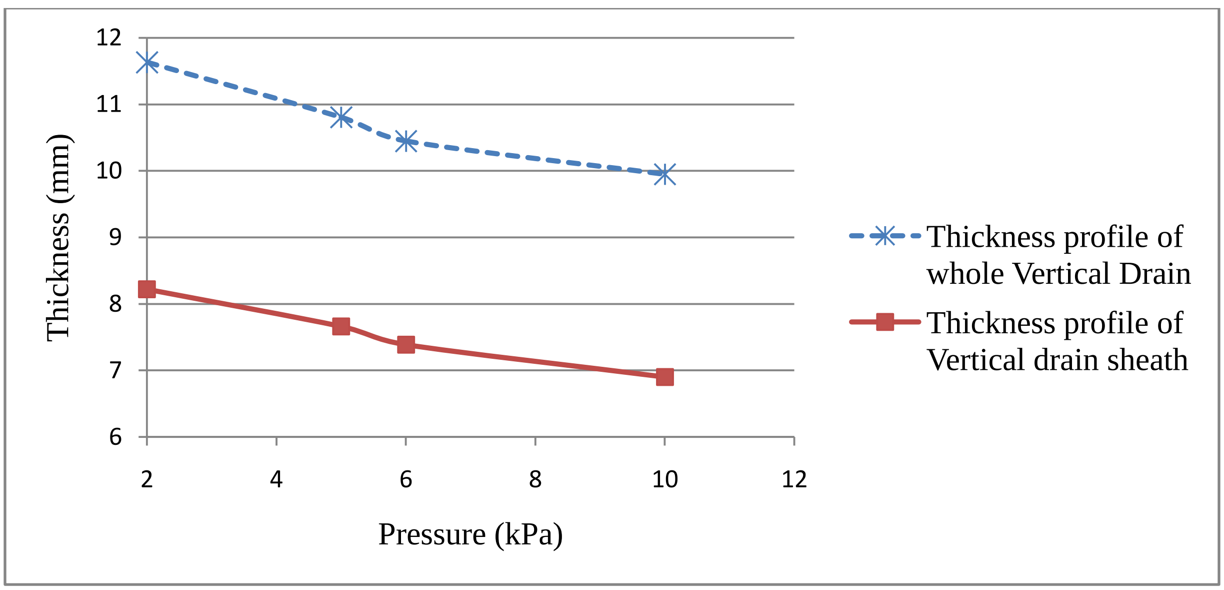


Fig. 10.1. Effect of pressure on thickness of jute braided vertical drain

It is clear from the tested AOS value and water permeability values that a proto-type vertical drain sample has been obtained. However, actual field trials of the product in land reclamation / ground improvement projects are must to establish its efficacy. Hence, further research is needed to modify the product (with respect to AOS, water permeability, discharge capacity etc.) for ensuring desired field performance which is beyond the scope of the present project.

11. COST CALCULATION OF JUTE BRAIDED SAPLING SLEEVE/ BAG

11.1. IJIRA method

The input variables:

1. Braided bag mass: 40 g
2. Braided construction employed: Regular (2/2) tri-axial
3. Number of axial tapes: 24
4. Number of spindles: 48
5. Number of braiding yarns per spindle: 2 (8 lb/ spyndle jute yarn is used)
6. Present cost of 8 lb/ spyndle jute yarn: Rs. 60000/ MT
7. Present cost of TD6 raw jute: Rs. 22000/ MT
8. Cost of processing up to finisher drawing: Rs. 4800/MT
9. Maximum take-up speed of the machine: 3825 mm/min
10. For the present jute braided construction,
    Maximum take-up speed adoptable: 2275 mm / min
11. Maximum machine delivery speed with the present braided construction (machine running at 60 % of maximum speed): 2.275 m/ min

<u>Calculation of machine running efficiency</u>

Length of yarn strand containing 2 jute yarns each of 8 lb/spyndle in full bobbin=975.4 m

Target machine bobbin capacity= 975.4 x 0.75 (75 % of existing braiding machine) = 731.55 m

Number of changes per day for braiding yarn = (2.275 x 60 x 24) / 731.55= 4.47

Length of axial tape per package = 237 m

No. of changes for axial tape per h = 0.58

Time needed for changing axial material in 24 h:

0.68 (= no. of changes per h) x 24 x 5 min. (=time needed for changing 24 axial tapes)

= 82.23 min.

Time needed for changing braiding yarn in 24 h:

4.47 (= no. of changes per day) x 24 min. (= time needed for changing 48 bobbins containing braiding yarns) = 107.46 min.

Machine stoppage time/ 24 h: (82.23 + 107.46) min. = 189.69 min. = 3.16 h.

Machine running efficiency: [(24 - machine stoppage time in hour) / 24] x 100 % =86.83 %

Number bags produced/ 24 h: 5600

Cost of raw material/ bag

Length of braided sleeve used per piece of sapling bag = 50.8 cm

Length of each braiding yarn in 50.8 cm of braided fabric = 66.8 cm.

Total length of braiding yarn in one sleeve = 6412.8 cm

Mass of braiding yarn per braided sleeve of length 50.8 cm = 17.62 g

Braiding yarn :	17.62 g x Rs. 0.06= Rs. 1.06/-
Jute tape:	22.33 g x Rs. 0.0268= Rs. 0.60/-

Raw material cost per bag : Rs. 1.66/-

Mechanical Processing cost for braiding sleeves /day

a) Electricity = 3.73 kW x 0.8 (= eff.) x 24h x Rs.7 = Rs. 502/-
b) Manpower cost = Rs. 200 x 1 hand (per braiding unit + winding unit) x 3 (= number of shifts) = Rs. 600
c) Machinery depreciation & Maintenance= Rs. 401
   (Machinery cost= Rs. 6 lakh at 15 % p.a. interest in 10 years, EMI= Rs.9680/-, Maintenance cost = Rs. 2352/ month @ Rs. 350/ MT/month)

Mechanical Processing cost/ bag: Rs. 0.27/-

- Cost of manufacturing per piece of bag: Rs. 1.93/- (excluding cost of adhesive application for manufacturing jute tape)

The calculation points out that the route to lowering cost is using less of jute yarn and more of tape as the latter is cheaper.

Processing cost for jute tape from 3rd drawing sliver

Cost of adhesive application per bag:

a) Cost of chemical
   Add-on = 2.41 % i.e. 24.1 g adhesive per kg of sliver
   Cost of adhesive used = Rs. 200.00 per kg
   Cost of 24.1 g adhesive for 1 kg tape = Rs. 4.82
   Mass of jute tape used per bag = 23 g
   Cost of adhesive= Rs. 0.11

b) Manpower cost
   Manpower required = 1 @ Rs. 200.00 per 8 h.
   Production per day
   = 15 (number of deliveries) x 15 m/ min. (machine del. speed) x 60 x 24 = 324000 m

Count of jute tape = 50 lb/ spyndle
Production in kg = 324000 x 1.09 x [50/ (2.2 x 14400)] = 557.4 kg
Cost of labour per piece of bag = Rs. (200 x 3 x 23)/ (557.4 x 1000) = Rs. 0.025
This production amount is sufficient to feed two braiding machines.

c) Cost of electricity for running the padding mangle
Motor capacity = 0.75 kW
Electricity cost per day = 0.75 kW x 0.8 (Eff.) x 24 h x @ Rs. 7.00= Rs. 100.80
Electricity cost per bag = Rs. (100.80 x 23)/ (557.4 x 1000) = Rs. 0.004

d) Cost of machine (Padding mangle) = Rs. 1.6 lakh at 15 % p.a. interest for 10 years
EMI per month = Rs. 2582.00
Machinery depreciation cost per bag = Rs. 0.02

e) Cost of drying
% wet pick up of sliver = 91
% dry size = 2.41
% water picked up = 88.59
Amount of water in 1000 g of jute tape = 885.9 g
If permissible residual moisture % of sized tape = 20
Hence, (885.9-200) g = 685.9 g moisture has to be evaporated
Latent heat of evaporation = 2258 J/ g (at 100 °C)
Workshop temperature = 30°C
Heat capacity = 4.18 J/ g / degree rise in temperature
Specific heat of jute = 1.36 J/ g / degree rise in temperature
So heat energy necessary to supply for 1 kg of jute sliver:
[{685.9 x 4.18 x (100-30)}+ (685.9 x 2258) + {1.36 x (100-30) x 1000}] Joule
= 1844.66 kJ
1 unit electrical energy = 1 kWh = 3600 kJ
1 kg of jute tape requires electrical energy for drying = 1844.66/ 3600 unit = 0.51 unit
Electrical unit consumption piece of bag = 0.51 x 0.04 unit
Cost of electricity for 1 bag @ Rs. 7 per unit = Rs. (0.51 x 0.04 x 7.00) = Rs. 0.14

In the drying cost calculation above, no heat loss is taken into consideration for the heating system. Depending on the efficiency of the drying system used, the above mentioned drying cost would increase. So, one has to judiciously select the drying system keeping under consideration of several factors, e.g., capital cost of the system, efficiency, production rate, budget, etc. If it is assumed that the heating efficiency of the drying system is 50 %, then electrical energy consumed for drying would be just doubled.

Hence, cost of electricity for drying per piece of bag @ Rs. 7 per unit = Rs. 0.28.

Total adhesive application cost per bag: Rs. 0.44

Cost of manufacturing per piece of bag

Rs. 1.93 (Raw material + Mechanical processing) + Rs. 0.44 (adhesive application) = Rs. 2.37 (without any profit)

Considering 10 % profit, price of jute braided sapling bag = **Rs. 2.60** per piece

Price per 1000 bags = Rs. 2600/-

Price/ MT of such bags = Rs. 65000/-

11.2. Standard Jute Mill method- for Composite Jute Mill

Table 20: Important technical data used in cost-calculation: Standard Jute Mill method

Technical data	Sample 'A'	Sample 'B'
Bag size (L cm x W cm)	22 x 15	28 x 15 (single layer)
Bag weight	40 g	24 g
Bags/ MT	25000	41666
No. of bags produced/day	5600	10748
Sliver count (lb/ spyndle)	60	60
Cost of sliver (Rs./kg)	30.80	30.80
Yarn count (lb/ spyndle)	8	8
Cost of yarn (Rs/ kg)	60	60
Yarn content (%)	42	42
Sliver content (%)	58	58

Table 21: Break-up of cost: Important cost- elements: Standard Jute Mill method

Cost items	Sample 'A'		Sample 'B'	
	Rs/ MT	Rs/ 1000 bags	Rs./ MT	Rs/ 1000 bags
1. Raw Material a) Jute yarn b) Jute sliver	 25200.00 17864.00	 1008.00 714.56	 25200.00 17864.00	 604.80 428.74
Total raw material cost	**43064.00**	**1722.56**	**43064.00**	**1033.54**
2. Labour	21562.50	862.50	21562.50	517.50
3. Energy	7160.00	286.40	7160.00	171.84
4. Stores(Direct & Indirect)	7784.00	311.20	7784.00	186.72
5. Other overhead & Indirect cost[50 % labour cost]	10781.00	431.24	10781.00	258.74
6. Depreciation & others (Annexure-1)	2610.00	104.40	2610.00	62.70
Total manufacturing cost	**49897.50**	**1995.74**	**49897.50**	**1197.50**
7. Profit (@10 %)	9296.15	371.83	9296.15	223.10
Grand total	**102257.65**	**4090.13**	**102257.65**	**2454.14**

N.B. : Ref. **Appendix-iii**

11.3. For green project - entrepreneur-run manufacturing unit

1. Machinery required:
   No. of braiding machines - 2
   No. of modified padding mangle - 1
2. Capital investment = Rs.[(2 x @6,00,000) + (1 x @ 2,00,000)] = Rs. 14, 00, 000
3. Other investments for land, building, etc = Rs. 10 to 15 lakh
4. Production per day = 500 kg (approx.)
   No. of bags per day = 11200
   No. of working days/month = 26
   No. of bags produced per month = 291200
   If, profit per bag is Rs. 0.50
   Monthly income from selling of jute braided sapling bag = Rs. 1, 45, 600.00
   Bank interest rate: 12 % per annum
   Turn-over period estimation:
   n x 145600 = {1400000 x (1+.12)}
   Where, n = turn-over period in month
   Therefore, n/12 = 0.89 years.

11.4. Cost of jute woven sapling bag and nursery polybags

The ex-factory price of hessian 305 g/m^2 fabric: Rs. 90 per kg

Mass per woven bag of dimension, 23 cm (L) x 13 cm (W) = 22 g

Cost of raw material, i.e., fabric per bag = Rs. 1.98

Price of jute woven sapling bag with profit

= Raw material cost + Conversion cost + Profit

= Rs. 5.00 per bag

Prices of polybags of different sizes in Kolkata in December 2010

Dimension of polybag (Length x Flat width)	Price (in Rs.)/ bag
7” x 6”	0.46
8” x 6.75”	0.59
12.5” x 12.5”	2.09

12. CONCLUSIONS WITH RECOMMENDATIONS - a way forward

12.1. Salient Features and Prospects of the Developed Technology

The features of the developed technology (the machine and the process) for the sapling bag product manifest in a unique sleeve which is primarily an axial assemblage of tapes. By changing width of each tape, total number of tapes and inter-tape spacing, the circumference of the resultant sleeve can be adjusted. For example, a larger mandrel can deliver a wider sleeve without changing the number and width of tapes. It is therefore possible to generate sleeves of varying dimensions on the developed machine by manipulating the three variables in conjunction with the machine rpm and take-up speed. A jute braided sapling bag product has been developed from the jute braided sleeves prepared employing the mentioned technology.

The braiding yarns of the resultant sleeve play a marginal role. They simply integrate the tapes into the fabric. Properties of these yarns are of no great consequence either during braiding or during subsequent utilization of the sleeve. Indeed the tapes play the central role in braiding as also in the end-use. Hence, optimizing the production and properties of these tapes is of vital importance.

Tapes should be as wide as possible, as thin as possible and as cheap as possible. The maximum width of tape is governed by the braiding machine design, the thinness of the tape is governed by the extent of the pressure that the padding mangle can generate while the cost is governed to a considerable extent by the cost of raw material. Undoubtedly, the process of converting multiple jute slivers into adhesive-bonded jute tapes of sufficient strength, that would withstand the strain of being pulled into the braiding zone from suitable packages, would also be a contributing factor to the cost of tape. It is hence evident that the commercial success of the technology developed so far depends to a great extent on the development of an economically viable and technically feasible process of manufacture of adhesive bonded *multiple* jute tapes of required dimensions and strength.

To manufacture multiple jute tapes at commercially acceptable level, development of a suitable machine is necessary. It should have six essential elements, viz., multiple sliver feed arrangement, two-roll single nip squeezing unit, adhesive application unit for roller-nip feeding, drying unit, take-up unit and winding unit. The most vital element of the machine would be the jute tape drying unit as the production speed is directly related to the drying efficiency of this unit. Hence, it should properly be designed to keep the heat loss at minimum. In the present work, a laboratory padding mangle is suitably modified to prepare a model system of the intended machine for demonstrating the basic principle of multiple jute tape manufacture. Some studies have been carried out utilizing this model to estimate the % wet pick up and % dry add-on of adhesive applied along with the properties of jute tapes prepared. But, optimization of the production process and jute tape properties is necessary.

The sleeves so produced on a suitable braiding machine can in principle be employed for protection, storage and transportation of natural materials. Sapling bag is one such example. With suitable manipulation one can create open mesh structures for storage and transport of fruits and vegetables, replacing the plastic mesh materials commonly found in outlets such as Mother Dairy. Another 'agrotextile' application of these jute braided sleeves of proper dimension has been identified and subsequently established as 'covering cloth' for ***Moss-sticks*** used for climbing plants having aerial roots in home gardens. Indeed the total technology (economic production of adhesive bonded tapes followed by suitable braiding of such tapes into sleeves and finally fabrication of the desired products from such sleeves) once properly developed can open up an entirely new vista of jute diversified products.

Similarly braided sleeves, suitably designed, can be used as Geotextiles in the form of Vertical Drain or even encasement of grout for reinforcement and protection of weak soil. To this end, a prototype (sample) structure of jute-coir braided vertical drain has been developed on the same braiding machine. Testing of a few of its necessary functional properties has been done. However, actual field trials of the product in land reclamation / ground improvement projects are must to establish its efficacy. Hence, further research is needed to modify it properly for ensuring desired field performance which is beyond the scope of the present project.

12.2. Price of Jute Braided Sapling Bag

The price per piece of the developed jute braided sapling bag of dimension, 9" (length) x 6" (flat width) has been estimated to be Rs. 2.60/- approximately. This value depends mainly upon raw material cost and jute tape drying cost. Higher proportion of jute tape in bag is desirable to reduce the cost as it is cheaper than yarn.

12.3. Commercial Version of Jute Braiding Machine

Based upon related calculation on machine running efficiency, commercially adoptable jute braiding machine should have two-third of the braiding yarn bobbin capacity of the present braiding machine and separate motor arrangements for braiding and fabric take-up operations without any Programmable Logic Control (PLC) facility. Evidently, the size, power consumption and cost of the commercial version would be lower than the present machine.

Appendix-i

The Agri-Horticultural Society of India

1, ALIPORE ROAD, KOLKATA 700 027

Website : www.agrihorticultureindia.com

Tel : 2479 1713, 2479 0834

Fax : 2479-3580

Email: ahsi@vsnl.net, ceo@agrihorticultureindia.com

ESTD 1820

AFFILIATED TO

THE ROYAL HORTICULTRUAL SOCIETY

THE ROYAL AGRICULTURAL SOCIETY

THE ROYAL NATIONAL ROSE SOCIETY

The Director,
Indian Jute Industries' Research Association (IJIRA),
17 Taratola Road, Kolkata- 700088.

Date: 13th April, 2012

Dear Sir,

Subject: Report on Field Trial related to performance of Jute Braided Sapling bag vis-à-vis Polythene Sapling Bag carried out at our premises from January'12 to March'12 by IJIRA Research Team headed by Dr Mahua Ghosh.

Project Ref: Jute Technology Mission, Mini-mission IV, Scheme No. 7.1/DDS/2, Project No. 04

In response to your letter dtd. 20th December, 2011 the field trial on assessment of efficacy of the jute braided sapling bag vis-à-vis commercial polythene sapling bag or polybag carried out by your research team at our premises , we are appending below our observations below for your kind perusal.

1. The experimentation was carried out on Sunflower saplings (*Helianthus annuus* L.), 15 Nos. saplings planted in jute braided sapling bags developed by IJIRA and rest 15 Nos. were planted in commercial polybags of comparable dimensions.
2. Mode of nursing with respect to dose and frequency of application of the manures and type/ composition of manures for all the saplings remained the same.
3. Type / composition and amount of potting media were same for all the saplings.
4. The jute braided sapling bags are free-draining and hygroscopic (capable of holding moisture) by nature in comparison to the synthetic polybags which are not at all free-draining and hygroscopic.
5. Jute braided sapling bags are porous due to its inherent structure. Consequently, air circulation inside the soil mass of those bags was good resulting in healthy root network formation within jute braided sapling bags. Unrestricted emergence of growing roots from jute braided bags was clearly visible. On the contrary, air movement and drain out water a few holes were made in polybags before soil-filling for facilitating emergence of the growing roots. In spite of making holes, air circulation was mostly restricted inside the polybags resulting in comparatively poor root network formation as those for jute bags. This was evident from emergence of lesser roots from some of those holes.

Contd...2....

6. It appeared to us that growth of stem base diameter and stem height of the saplings for the two types of bags/ containers were comparable.
7. Saplings planted in jute braided sapling bags were having more balanced physical attributes/ vigour than those planted in polybags.

In conclusion, we would like to state that performance of the jute braided sapling bags (developed by your organization) in caring nursery saplings was satisfactory. Hence, these eco-friendly products are capable to replace eco-damaging unfriendly synthetic polybags.

Wishing success for your research team in this regard.

Thanking you.

Yours faithfully,

SLRahman

Dr. S.L. Rahman,
Jt. Secretary

JT. SECRETARY
THE AGRI-HORTICULTURAL SOCIETY OF INDIA
1, ALIPORE ROAD, KOLKATA-700027

Appendix-ii

Let's Make India Green!

Think green
Think green mall

green mall

Dr. Mahuya Ghosh
Scientist, Technical Textile Division
Indian Jute Industries Research Association
17, Taratola Road, Kolkata – 700 088

Date: 13.02.2013

Dear Dr. Mahuya Ghosh,

With reference to your letter dated 27.12.2012, we are glad to provide our feedback about the Jute products as follows:

1. Jute Braided Sapling Bags.
   We used them for planting seedlings of Red Sandalwood & White Sandalwood. Plant is growing without any problem but it is very difficult to maintain the bag as it does not have a flat stiff bottom. Further, Jute would decay in 6 to 8 months and plant would require immediate repotting.
2. Jute Braided Sleeve flat width 8 cm. and 11 cm.
   We find these sleeves to be highly useful in making Climbing Sticks (commonly known as Moss Sticks) for climbing plants. We use plastic pipes of 1" to 2" dia in length of 1 mtr to 2.5 mtr. We warp them with about 1.5 cm coconut fibre and then cover with Jute Sleeves provided by you.

We would like to know what would be cost of these sleeves and consider this same for our commercial use.

Thanking you,

DINESH RAWAT

Sahayog Hortica Pvt. Ltd.
Bakhrahat Road, Samukpota, 24 Parganas (s),
West Bengal 743503, India
Ph. : + 91 33 2495 3003 / 9098
E-mail : dinesh@greenmall.in
love@greenkolkata.com,
www.greenmall.in, www.greenmall.in

Why wait for years for a mature garden ?
We are there to make available big trees & palms.

Appendix – iii

Back up data/ calculation for cost estimation of the jute braided sapling bag as per Standard Jute Mill

Estimation of energy cost

Name of machine	Power requirement (kW)	Total power requirement	Efficiency of motor (%)	Energy cost per unit	Energy cost/day	Bag prod/day	Cost of energy per kg
Braiding machine	3.78	5.28	80	@ Rs. 7.00	Rs. 709.63	224 kg	Rs. 3.16
Winding machine	0.75						
Modified Padding mangle	0.75						
Cost of drying for jute tape manufacture							
Electrical energy requirement to dry up 1 kg jute tape with 20 % residual moisture: 0.51 unit			Drying efficiency: 50 %	@ Rs. 7.00			Rs. 4.00
Total energy cost per kg of jute sleeve							Rs. 7.16

Estimation of Manpower/ Labour cost

No. of labourer per braiding machine + winding machine in 3 shifts per day = 1 x 3 = 3

No. of labourer per modified padding mangle in 3 shifts per day = 1 x 3 = 3

Number of labours for bag preparation (braided sleeve cutting + knotting +packing) / day

= 2 x 3 = 6

Number of additional labour for material handling and others per day = 1 x 3 = 3

Total no. of labourers = 15

Cost of labour per day =(@ Rs. 230.00 + 40% other benefits) x 15 = Rs. 4830.00

Production of jute sleeve per day: 5600 (= no. of bags produced per day) x 0.04 kg (=bag wt.)

= 224 kg

Cost of labour per MT = Rs. 4830.00 x (1000/224) = Rs. 21562.50

Stores

Cost of adhesive = Rs. 200.00 per kg

Cost of adhesive (Starch) for 2.4 % add-on per kg of jute braided sleeve:

0.58 kg (=jute tape content) x 0.024 x Rs. 200.00 = Rs. 2.78

Packaging & other stores: Rs. 5.00 per kg of braided sleeve

Store cost (Direct + Indirect): Rs. 7.78 per kg of jute sleeve

Overheads (50 % of labour cost): Rs. 10.78 per kg of braided sleeve

Cost of the project in composite mill

Cost of braiding machine: Rs. 6,00,000.00

Cost of jute tape producing padding mangle: Rs. 2,00,000.00

Total capital investment: Rs. 8,00,000.00

Depreciation cost @ 10 %: Rs. 80,000.00

Bank interest @ 12 %: Rs. 96,000.00

No. of working days/ year= 300

Depreciation & others: Rs. {1, 76, 000/ (300 x 224)} = Rs. 2.61 per kg of braided sleeve

Note:

1. The above calculation would be valid for composite mill. Subsidiary costs, like, building, land, etc. are excluded. Only machinery cost is included in the above exercise.