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An Overview on Test Standards for Evaluation of Jute Agrotextiles

Prof. Swapan Kumar Ghosh[1], Mr. Satyaranjan Bairagi[2], Mr. Rajib Bhattacharyya[3], Mr. Murari Mohan Mondal[4]
[1](Professor, Department of Jute and Fibre Technology, Calcutta University, Kolkata, India)
[2,3,4](Senior Research Fellow, Department of Jute and Fibre Technology, Calcutta University, Kolkata, India)

Abstract: *The growth of the Indian Economy is significantly reliant on the success of the agriculture community. Traditional methods are limited in their ability to increase yields with the current constraints of restricted space and water supply. In this context, Agrotextiles have proved to be an effective alternative that delivers strong results despite the constraints. Some of the benefits of the usage of agrotextiles are enhancing freshness in fruits and vegetables, prevents soil from drying, protection from harmful pesticides, yield increase etc. However, due to the growing environmental concern across the globe, scientists, technologists and researchers are in search of natural agrotextile and jute agrotextile (JAT) seems to be the most potential candidate in responding to their search. JAT is highly effective in agri-horticulture and forestry for higher agricultural yield. Extensive research works and field study have been conducted with encouraging results. Now, there is a dire need for quality control in terms of testing and evaluation of JAT demanding formulation of new international standards for testing. The existing test standards for synthetic agrotextiles for evaluating different end use property parameters are not uniform globally i.e., these test standards vary from country to country. However, in the field of standardization for testing of different properties of JAT there is a paucity of data for formulation of specifications and quality control guidelines. Test standards for synthetic agrotextiles understandably do not exactly apply to JAT. While study is on to develop exclusive test and design standard for JAT, there is need to adopt any of the existing standards for synthetic agrotextiles that cater to the majority of requirements in the interim period. The paper suggests adoption of ASTM standards for testing JAT because of the wide range of test standards available and their credibility.*

Keywords:*ASTM standards, European Standards, Jute Agrotextile (JAT), Synthetic Agrotextiles, Technical Textile,*

I. Introduction

Agriculture forms the backbone of the Indian Economy and one cannot disregard the significant role that agriculture plays in the Indian Economy and in the daily life of its citizens. Yet, food security continues to be a pressing issue in India. In light of this major challenge, Agrotextile utilization has helped the agriculture community in attaining increased yield and enhanced quality in agriculture produce. Amongst its various benefits, agrotextiles protect produce from harmful external elements and assist in better soil management. These benefits provide farmers with enhanced productivity and increased yields resulting in further socio-economic development of the stake holders within the agriculture community. Agro processing sector has experienced expansion during the last five decades, starting with a handful of facilities which were mainly operating at domestic level [1]. The selection of Agrotextile product depends on crop needs. Selection of the agro textiles is also greatly influenced by the geographical location. But for any application and supervision quality control tests are an essential part. Again, proper testing of technical textiles meant for agriculture is critical to ensure their effective performance. The standards evolved for this purpose relate to synthetic agrotextiles only and are not uniform. Table 3 shows the existing BIS standards for the different synthetic agrotextiles used in different agriculture and horticulture applications. The design is based on rigorous empirical exercise carried out individually in each country. The site conditions are apt to vary and so also the approach to design. While some sort of uniformity in testing methods could be achieved in case of synthetic agrotextiles after 'synthesizing' the standards available, no such standards have drawn up so far for agrotextiles made of different natural fibres such as Jute Agrotextiles (JATs). In absence of testing standards for JAT, standards for synthetic agrotextiles are presently adopted for agrotextiles made of natural fibres. In view of the growing demand of JAT in particular, it is felt necessary to evolve exclusive application-wise standards for JAT.

The selection of JAT for a particular application in agriculture area necessarily depends on adequate and suitable fabric properties and specific functional characteristics in respect of end-use requirements. If these properties are technically inadequate for a particular application considering the limited durability of JAT and other natural Agrotextiles, distress/failure could be a distinct possibility. On the other hand, if these properties meet the desired specifications in excess of the actual requirement, the selection of the fabric will understandably prove uneconomical. As the physical features and mechanical properties of natural [2] and man-made fibres distinctly differ, we need to decide specifications of JAT carefully.

II. National Standards for Agrotextiles

There are reportedly 21 Bureau of Indian Standards (BIS) for the manufacture, testing, etc., of various types of synthetic agrotextiles [3] namely, IS 15351:2008 for Laminated high density polyethylene (HDPE) woven fabric (Geo-membrane) for water proof lining, IS 15907:2010 for Agro textiles - High Density Polyethylene (HDPE) Woven Beds for Vermiculture – Specification, IS 16008:2012 for Agro Textiles - Shade Nets for Agriculture and Horticulture Purposes – Specification, etc.

2.1 International Standards for Agrotextiles

Most of the countries of Western Europe (e.g. Belgium, France Germany, Italy, the Netherlands, Switzerland and the United Kingdom) have national standards [4] on the construction, testing and use of various types of synthetic agrotextiles. There is already a large volume of trade in agrotextiles among the countries of Western Europe but standard procedures for testing different parameters of agrotextiles of the producer country may differ with that of the user country creating ambiguity about the conformity of the test results of the different parameters of the product in particular JAT. European Economic Community (EEC) has a number of European Committees for Standardization (CENs) for various disciplines and product groups. The decision to use a particular agrotextile material in any agricultural process will depend, among other things, on whether it complies with the specifications indicated for that material by the specialist engineer in the design of the project. As already stated different countries have developed their own standards for use of agrotextiles which enable the specialist consulting engineers and other users to specify clearly the products they want; in addition, standardized testing methods make it possible to compare products and results.

2.2 Issues

The question is about the specifications and testing methods to be adopted in the intervening period till such time the application-wise specifications for JAT are finalized and testing methods specific for JAT are decided. Although there are a few BIS standards existing for agrotextiles, there is a dire need for international standards for the agrotextiles [2]. Whilst the national standards of different countries for test methods recommend a unified approach for testing, the way in which the test results are applied to specify an agrotextile for a particular application could hardly be uniform. As there is hardly any difference between JAT and synthetic agrotextiles functionally, the standards available for synthetic agrotextiles are applied for JAT. As the standard testing methods of agrotextile are not uniform in developed countries and are somewhat sporadic in developing countries, ASTM standard testing methods for testing of different types of synthetic agrotextiles as well as JAT in most of the cases are being followed for the sake of uniformity. In India, BIS standards are followed where such standards exist for testing of JAT.

III. Speciality of Jute Fibre

Jute is one of the most versatile natural fibres and is second only to cotton in availability and variety of uses among vegetable fibres. It is a long, soft, shiny vegetable fibre that can be spun into coarse, strong threads. It falls into the bast fibre category (fibre collected from bast or skin of the plant) along with kenaf, industrial hemp, flax (linen), and ramie. It is produced from plants in the genus Corchorus, which has been classified in the family Tiliaceae, or more recently in Malvaceae. Two species of Jute [5] which are commonly cultivated are Corchorus capsularis (White Jute) and Corchorus olitorius (Tossa Jute). The fibres are off-white to brown, and 1–4 metres (3–12 feet) long. Jute fibre is grown abundantly in Bengal (India) and adjoining areas of Indian subcontinent. Retted jute fibers have three principal chemical constituents, namely α-cellulose, hemicelluloses, and lignin. The hemicelluloses consist of polysaccharides of comparatively low molecular weight built up from hexoses, pentoses, and uronic acid residues. In jute, capsularis and olitorius have similar analyses, although small differences occur among different fiber samples. In addition to the three principal constituents, jute contains minor constituents such as fats and waxes inorganic matter, nitrogenous matter and traces of pigments [6]. The details of chemical composition [7, 8] of the jute fibre is given in Table – 1 and the fibre properties of most widely used fibres for producing Geotextiles like jute, polyester and polypropylene are depicted below in Table-2.

Table- 1: Average chemical composition (in percent of bone dry weight of the fibre) of jute [8] *C. Capsularis* (White Jute), *C. Olitorius* (Tossa Jute).

Constituent	***C. Capsularis* (White Jute)**	***C. Olitorius* (Tossa Jute)**
Cellulose*	60.0 – 63.0	58.0 – 59.0
Lignin	12.0 - 13.0	13.0 – 14.0
Hemicellulose**	21.0 - 24.0	22.0 - 25.0
Fats and waxes	0.4 - 1.0	0.4 - 0.9
Proteins or nitrogenous matter etc. (% nitrogen x 6.25)	0.8 - 1.87	0.8 - 1.56
Pectins	0.2 – 0.5	0.2 - 0.5
Mineral matter (Ash)	0.7 – 1.2	0.5 – 1.2
* Major constituents of jute-cellulose include glucosan (55.0 – 59.0%), xylan (1.8 – 3.0%) polyuronide (0.8 – 1.4%). **Major constituents of jute-hemicellulose include xylan or pentosan (15.5-16.5%), hexosan (2.0 – 4.0%), polyuronide (3.0 - 5.0%) and acetyl content (3.0-3.8%).		

Table- 2: Properties of jute fibre [9-18] in contrast with man-made fibre.

Sl. No.	**Properties**	**Jute**	**Polyester**	**Polypropylene**
01.	Specific gravity [21]	1.48	1.38	0.91
02.	Tenacity, g/d	3 to 5	2 to 9.2	2.5 to 5.5
03.	Breaking Elongation, %	0.8 to 2	10 to 14.5	14 to 100
04.	Elastic recovery, %	75 to 85	57 to 99	75 to 95
05.	Moisture regain [22], At 65% R.H. and 27^0C.	12.5 to 13.8	0.4 to 4.0	0.01
06.	Effect of heat	It does not melt. Up to 180^0C there is no major wt. loss and tenacity loss. However hemi cellulose degrades around 293^0C and other constituents at higher temperature.	Sticks at 180^0C and Melts at 230^0 – 240^0C	Softens at 143^0 – 154^0C, melts at 160^0C & decomposes at 288^0C
07.	Effect of acid /alkalis	Good resistant to dilute organic and mineral acids at room temperature but degrades in conc. mineral acids. Affected by hot alkali.	Good resistance at room temperature disintegrates in conc. hot alkali. Excellent resistance to acids.	Excellent resistance to conc. acid and alkalis.
08.	Effect of bleaches & solvents	Resistant to H_2O_2 bleaching conditions. Excellent resistant to organic solvents. However, affected by strong oxidizing agents.	Excellent resistance to bleaches & oxidizing agents.	Resistance to bleaches & solvents. Chlorinated Hydrocarbon cause swelling & dissolves at 160F and higher.

IV. BIS Standards Available

The following standards formulated for testing of synthetic Agrotextiles are given in Table – 3 below.

Table - 3: Standards [3] followed for Agrotextile Testing

AGROTECH		
SL. No.	BIS Standard	Description
1.	IS 15351:2008	Textiles- Laminated high density polyethylene (HDPE) woven fabric (Geo-membrane) for water proof lining (First revision)
2.	IS 15907:2010	Agro textiles - High Density Polyethylene (HDPE) Woven Beds for Vermiculture - Specification
3.	IS 4401:2006	Textiles-Twisted nylon fishnet twines (fifth revision)
4.	IS 4402:2005 /ISO 1107:2003	Textiles - Fishing nets - Netting - Basic terms and definitions (second revision)
5.	IS 4640:1993 /ISO 858:1973	Fishing nets - Designation of netting yarns in the tex system (first revision)
6.	IS 4641:2005 /ISO 1530:2003	Textiles - Fishing nets - Description and designation of knotted netting (second revision)
7.	IS 5815(Part 4):1993 /ISO 1805:1973	Fishing nets: Determination of breaking load and knot breaking load of netting yarns (first revision)
8.	IS 5815(Part 5):2005 /ISO 1806:2002	Textiles - Fishing nets - Determination of mesh breaking force of netting (second revision)
9.	IS 5815(Part 6):1993 / ISO 3090:1974	Netting yarns - Determination of change in length after immersion in water (first revision)
10.	IS 5815(Part 7):1993 / ISO 3790:1976	Fishing nets - Determination of elongation of netting yarns (first revision)
11.	IS 6348:1971	Basic terms for hanging of netting
12.	IS 6920:1993 /ISO 1532:1973	Fishing nets - Cutting knotted netting to shape ('Tapering')
13.	IS 8746:1993 /ISO 3660:1976	Fishing nets - Mounting and joining of netting - Terms and illustrations (first revision)

14.	IS 9945:1999	Fishing nets - Method for determination of taper ratio and cutting rate (first revision)
15.	IS 15788:2008	Fishing nets - Method of test for determination of mesh size - Opening of mesh
16.	IS 15789:2008	Fishing nets - Method of test for determination of mesh size - Length of mesh
17.	IS 5508 (Parts 1 to 24)	Guides for fishing gears
18.	IS 7533:2003	Polyamide monofilament line for fishing
19.	IS 14287:1995	PP Multifilament netting twine
20.	IS 6347:2003	PE Monofilament twine for fishing
21.	IS 16008:2012	Agro Textiles - Shade Nets for Agriculture and Horticulture Purposes – Specification *(Clubbed the specifications of 3 Shade net standards, i.e. Specifications for Shade net 50%, 75% and 90% for Agriculture Application. Thus, have 1 standard against 4 proposed standards)*

V. Problem of using the existing BIS Standards for Synthetic Agrotextiles in JAT

Growing market offers new possibilities for jute in technical textile sector [19, 20]. In order to meet the challenges in this area, JAT should conform to the stringent quality specifications. This may be achieved only by following the standards established specifically for JAT [21]. But as these specific standards for JAT are yet to be formulated and published, existing standards for synthetic agrotextiles are adopted which could be sometimes misleading for JAT. Separate specific standards are required for JAT as the different property parameters of JAT like physical, mechanical, and hydraulic and endurance properties are not similar to synthetic agrotextile. Apart from these, behavior of JAT on imposition of extraneous load and its withdrawal are different from synthetic agrotextiles. It is found that during straining, elongation at break for synthetic agrotextiles is much higher than that of JAT and their retractive behavior is different. In case of JAT properties for less than 50% are only applicable. Behavioral differences between JAT and synthetic agrotextiles demand formulation of separate standards for JAT for assessing of different property parameters in the laboratory for its acceptance globally. This will not only meet the technical requirements for assessing the property of JAT but also make successful marketing of JAT globally.

VI. Suitability of ASTM Standards as an interim option

There are different BIS standards available for synthetic agrotextiles. As there is no unified standard for JAT, BIS testing standards are considered the most preferred option for JAT testing till such time exclusive JAT standards are formulated and accepted. ASTM standards are accepted globally for its authenticity of all the existing standards. Testing parameters of JAT which are measured for finding its potential applications in different geotechnical applications are given in Table - 4.

Table-4: Properties of JAT [22]

	Erosion Control, & Afforestation				**Weed Management**	
	Woven				**Non-Woven**	
Criteria	**Conventional**	**Type-1**	**Type-2**	**Type-3**	**Type-1**	**Type-2**
Weight(g/m^2)	500	400	300	300	500	750
Thickness(mm)	5	3	3	2	6	8
Open Area (%)	60	40	60	70	0	0
Threads/dm Warp X Weft	6.5 × 4.5	34 × 15	17 × 4.6	11 × 12	-	-
Width(cm)	122	122	122	122	150	150
Length(m)	70	100	100	100	50	50
Water absorption capacity(%)	600	500	400	350	650	700
Tensile strength (kN/m) WarpX Weft	17.5 × 7.5	12 × 10	10 × 7.5	10 × 10	5 × 6	7 × 8
Elongation at Break (%) Warp X Weft	11 × 15	10 × 12	10 × 15	12 × 12	20 × 25	25 × 30

VII. Conclusions

Natural technical textile in the name of Jute Agrotextile (JAT) is highly effective in agri-horticulture and forestry for higher agricultural yield. Extensive R & D work and field study has been conducted by research Organizations in this field with encouraging results. Efficacy of the products have been established and documented. JAT helps faster growth of vegetation naturally. It is a natural fabric that helps retain soil humidity at conducive levels, arrests desiccation of soil and attenuates extremes of temperature due to its inherent capacity to absorb water/moisture to the tune of 5 times of its dry weight. Jute coalesces with soil after biodegradation, increases its permeability and supplementing its nutrient level. JAT fosters growth of plant in arid and semi- arid zones much faster than under control conditions without use of manures. Non- Woven JAT can suppress weed-growth effectively. JAT provides all these advantages without affecting eco-ambience

adversely at affordable and competitive cost. It has been envisaged that some of such products like, jute sleeve, nonwoven agro mulching sheet, fabric for plant wrapping etc. can be conveniently fabricated in rural areas with an ultimate impact on rural economy.

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