Weaving flax: A Way forward

Ritu Pandey

Received on 10 Aug. 2015, accepted on 20 Oct 2015

Abstract

Flax (Linum usitatissimum L.) is one of the oldest textile fibres. Flax fibres are found in the outer regions of the flax plant stem between the cuticle and the woody core tissues. flax type accessions (FT) utilized in the study were grown as per recommended agricultural practices. Plant stalks were harvested and retted for further scutching and fibre extraction. Flax fibre extraction was done using traditional water retting method. Befama carding machine of the woollen spinning system was used for the carding operation of flax fibres. Roving prepared in Befana card machine were spun using ring spinning system operated by electrical power. Flax spun yarns were woven into plain weave in the handloom and physical properties of bleached and the unbleached fabric was tested. Tensile strength and elongation at break of bleached fabric was found to be higher than unbleached one. Bleaching not only improved the fabric tensile strength and elongation, but also improved the compactness of the fabric. Flax fabric was successfully given water repellent finish using fluorocarbon polymers (FCP), and was stitched by machine into water carrier bag. FCP imparted both water and oil repellency on fabric without affecting the natural looks and feel of the fabric.

Keywords: Natural fibres, flax fibres, weaving, water repellent

Introduction

Common flax (Linum usitatissimum L.) was one of the first crops domesticated by man. Flax is thought to have originated in the Mediterranean region of Europe; the Swiss Lake dweller people of the Stone Age apparently produced flax utilizing the fibre as well as the seed. Linen cloth made from flax was used to wrap the mummies in the early Egyptian tombs. Presently the major fibre flax producing countries are the Soviet Union, Poland and France (Oplinger, 2013). Flax in India is primarily produced for its oil. Linseed is an important oilseed crop grown for industrial uses in printing ink, paint and varnish besides human consumption as nutritional flax seeds. Flax fibres are found in the outer regions of the stem between the cuticle and woody core tissues. Flax fibres are sought in textiles due to its favourable qualities like high hygroscopicity, high absorption, and anti-electrostatic properties, which provide comfortable clothing. Flax fibre accounts for ~2% of the

---

Ritu Pandey, Assistant Professor, Department of Textiles & Clothing, Faculty of Home Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur-208002, Uttar Pradesh, Email: ritupandey70@gmail.com

production of natural fibres in India. Import of linseed commodity by India increased 75% in the last five years, and in the year 2011-12 reached Rs. 396.36 crores. At present, India imports flax about 0.18 million tonnes to meet our indigenous demand, particularly in defense. The utilization of available flax plant for the textile purpose will not only increase the income of farmers but also help in employment generation for rural and urban masses along with smart earnings of foreign currency to improve agro socio-economy. In the present study, the emphasis has been put to determine the suitability of indigenous flax accessions for its spinning efficiency and thereby various end uses.

Materials and Methods

Flax accessions were grown in the month of November'2009 and 2010 as per recommended agricultural practices at Sunhemp Research Institute, Uttar Pradesh. It's a winter crop and grows well on deep moisture retentive soil. Row spacing for flax accessions was 30cm, plant height was 105cm to 135cm and fibre yield between 15 to 17 Q/ha. Flax accessions were hand pulled at dough stage (just before maturing of seed capsule) in the month of March'2011. Agronomical and yield attributes of flax accessions cultivated for the study are presented in Table 1. Stalks were cut into technical height (height from ground level to first fruiting branch) using hand cutter to obtain the middle portion of the stalk.

Table 1: Agronomical and yield attributes of flax accessions

Year	2009	2010
Plant height (cm)	105- 135	105- 135
Row spacing (cm)	20- 30	20-30
Fibre yield (Q/ha)	15- 17	15-17
Technical height (cm)	95cm	92
Stem diameter (mm)	2.1	1.8
Line fibre length (cm)	80	79
Fibre tenacity (g/d)	3.1	3.7
Fibre elongation at break (%)	2.34	2.32

Water retting

Flax fibre extraction was done using traditional water retting method. Retting is defined for flax as the "subjection of crop or deseeded straw to chemical or biological treatment to make the fibre bundles more easily separable from the woody part of the stem. Water retting depends upon colonization and partial plant biodegradation by microorganisms in the retting consortium and is influenced by environmental conditions. Fungi and bacteria partially decompose the pectinaceous and matrix substances to separate cellulose fibres from shives of a flax plant. Flax stalks after cutting into technical height were placed in retting tank lined with plastic sheet and submerged in stagnant water for 72 hours. Weight was put over flax stalk to fully submerge it. Material liquor ratio was 1:30. The retted samples were dried under sun. Sun dried stalk was further scutched and heckled to obtain flax fibres free from shives and woody parts.

Carding and spinning

Cleaned fibres recovered after complete shive and vegetable matter removal in scutching and further processing such as scouring, degumming and bleaching, were stapled into 9.5cm length using mechanical cutters prior to carding operation. Fibres were processed using a combination of enzyme and chelating agents and spun on the woollen spinning system. The softening of fibres was done prior to spinning by hand with the aid of batching oil, (castor oil) which facilitated spinning. In carding operation parallelization of the fibres was done followed by removal of damaged, short and entangled fibres along with other wastes. Flax fibres were carded and roving prepared was successfully spun on ring spinning in the woollen system. The machine consisted of 12 creels for 120 ends. Fibre waste recovered after carding operation was utilized to prepare sanitary napkin as per mandatory standards AATCC and ENESO. Roving prepared in the befama Card machine were spun using the befama ring spinning system.

Weaving

Flax spun yarn was woven into plain weave on a hand loom. To prepare linen fabric, 2ply flax yarn was used as warp yarn and single ply flax yarn was used in the weft direction. Fabric width was kept 65cm and the 150cm long fabric was prepared. Flax/cotton union fabric was prepared using cotton yarn in warp direction and flax yarn in the weft direction. Fabric width to length ratio of flax/cotton union fabric was 95x150cm. Woven fabric was scoured, bleached and finished with water repellent finish to prepare water carrier bag suitable for use in the desert area.

Besides production through the mechanical process, untreated flax fibres were spun through the traditional method using the spindle. In this method, one end of flax fibres was secured onto spindle with a cord and twist was imparted by finger from other end of fibres. Fibres were joined at the top end of fibres while giving the twist to the fibres. This produced a hairy, strong, crisp, textured yarn. Hand spun yarn was used to prepare thick cord and also dyed and woven into plain weave to prepare durri, foot mats etc.

Physical properties of yarn and woven fabric

Physico-mechanical parameters of yarn and fabric were evaluated. Flax yarn and fabric samples were conditioned and tested at a temperature of 27 ± 20C and 65 ± 2% RH. Yarn count, twist, tenacity, elongation percent and count strength product (CSP) were determined as per BSI specifications for testing. Yarn strength and elongation percent were measured on Universal Testing Machine as per IS 1670-1991 (RA-2007). Gauge length was kept 500mm and speed of the jaw was 300mm/min. Yarn count and the twist was measured directly using Beasley's balance and twist tester respectively (Kamal Metals, Ahmedabad). Lea strength was measured using Presto tensile strength tester. Count strength product (CSP) was determined using following formula:

CSP= Lea strength (lb) x Resultant count (Ne)

Fabric strength and elongation percent were determined on Universal Testing Machine using ravel strip method as per IS 1969-1985 (RA- 2006). Gauge length was kept 200mm and constant rate of the traverse was 300mm/minute. Breaking strength and elongation at break of flax and flax-cotton union fabric prior to bleaching and after bleached wastes

Tensile strength = L/(BxT) kg/cm^2

L= breaking load in kg

B= Width of the test specimen in cm

T= Thickness of test specimen in cm

Fabric weight/m^2 was determined using GSM cutter.

Fabric density was calculated using formula:

Density (Kg/m^3)= mass (kg)/Volume (m^3)

= GSM/Area x fabric thickness in meters

Ends/inch, picks/inch and fabric count of the samples was measured using piqué glasses. Fabric thickness was measured using thickness gauge prescribed for textile materials. Rate of water absorption (wetting time) of unscoured and bleached fabric was determined using spray tester (AATCC 79-1992). Ten readings of wetting time were recorded and the time averaged.

Finishing

Bleached fabric was given water resistant finish, fluorocarbon chemical for use as water carrier bag. Fluorocarbon polymers (FCP), act as a plastic sheet on top of the fabric and any liquid coming in contact is repelled and cannot pass through the barrier. If the critical surface tension of the solid is less than the surface tension of the liquid, the fabric will repel the liquid. Thus water repellence can be obtained in case the critical surface tension of solid s smaller than the surface tension of liquid. To achieve water repellence, bleached fabric was submerged in 20g/l fluorocarbon solution for few minutes and subsequently passed through padding mangle till the wet pick up is 70 to 80%. Fabric was dried at 110^0C and curing for 3 minutes was done at 160^0C. Water repellent fabric was stitched into water carrier bag for experimental trial.

Results and discussion

Flax fibres were successfully spun on ring spinning in the woollen system. Physical properties of ring spun and hand spun yarn is shown in Table 2. The tenacity of traditional hand spun yarn was considerably more than ring spun yarn. This is due to stapling of flax yarn for use in ring spinning, whereas line fibres were used for hand spinning. Line fibres produced stronger yarn (8.94g/tex) as compared to short stapled fibres of flax. However, elongation at break of ring spun yarn (9.49%) was considerably more than hand spun yarn (4.36%).

Hand spun yarns were strong and suitable for weaving sacking and packaging fabric. Hand spun yarns were used to prepare strong rope of different thicknesses for use as cord for various uses such as crop bailing twine, elephant and camel thread, shipping cord etc. It can also be used as stuffer yarn for wire rope and cord and upholstery stuffing in the furniture industry. Hand spun yarn was used to prepare thick cord for various uses such as elephant and camel thread and crop bailing twine. Dyed hand spun yarn was also used to make durri/ foot mats using plain weave and also utility articles such as lamp shade and decorative wall hanging.

Table 2: Physical properties of flax yarn

Test parameters	**Single ply flax yarn**	**Two ply Flax yarn**	**Hand spun yarn**
Twist per inch	11.7	8.85	5.16
Count	567.79 tex, 3.4s	637.69tex, 3s	913.52
Lea strength (lb)	176 (79.83kg)	255.2 (115.76kg)	
CSP	183.04	118.16	
Breaking strength (g)	706.36	1478.44	8677.27, 8.94g/tex
Elongation %	9.49	12.31	3.44

Physical properties of fabric

Table 3 depicts fabric specification of flax-cotton union fabric and pure flax. Flax spun yarns were woven into plain weave in the handloom. Flax yarns were doubled into two-ply, using a twisting machine, to be used as warp yarn in pure flax fabric. This considerably improved operating speed as well as the reasonable efficiency of looms. In another sample cotton yarn was used as warp yarn to prepare flax-cotton union fabric. The fabric was bleached with hydrogen peroxide and physical properties of bleached and unbleached fabrics were tested.

Table 3: Fabric specifications

Test parameters	Test results			
	Flax-cotton union fabric (Untreated)	Flax-cotton union fabric (Bleached)	Flax fabric (Untreated)	Flax fabric (Bleached)
Fabric weight (GSM)	766	738	1418	1491
Fabric thickness (mm)	1.92	2.43	3.64	3.58
Fabric density (kg/m^3)	398.96	303.70	389.56	428.45
Ends per inch (EPI)	13	12	6	6
Picks per inch (PPI)	30	30	38	46
Fabric cost (Rs/m^2)	92.1	-	97.45	-

Tensile strength and elongation percent of flax-cotton union fabric and flax fabric was more in weft direction than in warp direction (Table 4). The reason for this may be due to higher PPI than EPI in the fabric. Warp yarn in flax fabric being a two-ply yarn was thicker than weft yarn and therefore lesser EPI than PPI in the fabric. Tensile strength and elongation percent of bleached flax fabric is more than untreated flax fabric in both directions. Bleaching not only improved the tensile strength and elongation at break of the fabric but also made the fabric more compact and soft to touch. The Higher density of bleached fabric as compared to untreated one improved the fabric physical properties.

Hand spun yarn was used in the weft direction and polyester yarn was used in warp direction to prepare plain woven durri and foot mats on a handloom. Durri fabric was strong in weft direction (254.66kg) due to the presence of strong hand spun yarn in weft direction as compared to warp direction (20.33kg).

Sample/ Ends/ picks/ GSM/ elongation at break

Hand spun fabric/ 6/ 10/ 1330/ 20 - 25

Table 4: Physical properties of fabric

Test parameters	Flax-cotton union fabric (Untreated)		Flax-cotton union fabric (Bleached)		Flax fabric (Untreated)		Flax fabric (Bleached)	
	Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft
Breaking Strength (kg)	45.8	55.20	45.98	46.78	17.52	78.16	19.85	77.68
Tensile strength (Kg/cm^3)	47.71	57.5	37.84	38.50	9.63	42.95	11.41	44.64
Elongation at break (%)	19.76	22.99	16.57	22.54	5.95	18.45	8.86	28.34
Fabric absorbency (Wetting time in sec)	5.8		2		5.2		2.4	

The shorter the average wetting time, the more absorbent is the textile. Five seconds or less is generally considered to represent adequate absorbency. Wetting time of bleached flax-cotton union fabric and flax fabric was less than three seconds and of unbleached fabric was less than six seconds. The bleached fabric was degummed and scoured prior to the bleaching process. The result suggests that bleaching improved the wet ability of flax-cotton union fabric and pure fabric.

Finishing

Flax fabric was given water repellent finish FCP, and machine stitched into water carrier bag. Water carrier bag being light weight can be used in the desert area to carry water to long distance. FCP treatment reduced the surface energy of fabric to the level less than 15 to 20 dyne/cm. Since the surface energy of water is 72.6 dyne/cm, water cannot pass through the finished fabric. FCP imparted both water and oil repellency on fabric without affecting the natural looks and feel of the fabric. When a drop of water was added on the fabric surface, there was drop formation and it formed a contact angle of > 80 with it. The contact angle is dependent on the surface energy {SE} of the surface and the surface tension {ST} of the liquid. Wetting occurs only when ST <SE, the energy of the surface depends on the presence of fluorocarbon

groups on it. If the contact angle is > 90, there is hardly any wetting. The contact angle of > 80 on flax fabric slightly wetted the fabric but did not allow passing the water through it. The fabric is able to breath after application of the water repellent finish. In hot summer evaporation of the water from water bag in small droplets form will keep the water kept in the bag cool as well.

Conclusion

Line fibres produced stronger yarn (8.94g/tex) and fabric as compared to short stapled fibres of flax. However, elongation at break of ring spun yarn (9.49%) was considerably more than hand spun yarn (4.36%). Ring spun and hand spun yarns were woven into plain weave on a handloom. Tensile strength and elongation at break of flax fabric was more in bleached fabric as compared to unbleached fabric, due to higher density of bleached fabric. Bleaching improved the flexibility and compactness of the fabric. Fabric prepared was finished using water repellent finish FCP, and machine stitched into water carrier bag. FCP treatment makes the fabric water and oil repellent without affecting the natural looks and feels of the fabric. Lightweight water bag is useful in desert area. The flax textile industry in India can now look forward to meeting its major raw material requirements exclusively through indigenous supply of flax.

References

1. Akin, D. E., Dodd, R. B. and Faulk, J. A. (2005). Pilot plant for processing flax fibre. Industrial Crops and Products, 21: 369-378..
2. Akin, D. E., Rigsby, L. L. and Perkins, W. (1999). Quality properties of flax fibres retted with enzymes. Textile Res. J., 69:747-753.
3. Anderson, J., Sparnins, E., Joffe, R. and Wallstorm, L. (2005). Strength distribution of elementary flax fibres. Composite Science and Technology. 65: (3-4)693-702.
4. Baley, C. (2002). Analysis of the flax fibres tensile behaviour and analysis of the tensile stiffness increase. Composites, 33: 939-948.
5. Booth, I., Harwood, R. J., Wyatt, J. L. and Grishanov, S. (2004). A comparative study of the characteristics of fibre-flax (Linum usitatissimum). Industrial Crops and Products, 20(1): 89-95.
6. Dass, P. K., Nag, D., Debnath, S. and Nayak, L. K. (2010). Machinery for extraction and traditional spinning of plant fibres. Indian Journal of Traditional Knowledge, 9: (2)386-393.
7. Faulk, J. A., Akin, D. E., Dodd, R. B. and Mcalister, D. D. (2002). Flax fibre: potential for a new crop in the southeast. In: Janick, J. and Whipkey, A. (eds), Trends in new crops and new uses. ASHS Press Alexandria, VA, 361-370.
8. Hamilton, I. (1986). Linen. Textiles, 15:30-34.

9. Husain, K., Malik, Y.P., Srivastava, R.L. and Pandey, R. (2009) . Production technology and industrial uses of dual purpose linseed: An overview. Indian Journal of Agronomy, 54: (4)374-379.
10. Kim, J.H.; Kim, S.Y. and Choe, E.K. (2005). The beneficial influence of enzymatic scouring on cotton properties. J. Nat. Fibres, 2: 39-52.
11. Kirby, R. H. (1963). Vegetable fibres, New York: Inter Science Publishers Inc.
12. Kozlowski, R. (2009). Green fibres and their potential in diversified applications. http://www.fao.org/DOCREP/004/Y1873E/y1873eOb.htm
13. Mukherjee, P. K. (1988). Ramie holds vast potential. The Indian Textile Journal, 108: 42-45.
14. Mahapatra, N. N. (1998). Grafting flax. The Indian Textile Journal. 109: (2)50-52.
15. Marshal, G. (1998). Flax breeding and utilization, London: Kluver Academic Publishers.
16. Narayan, K. (1987). Flax, the northern silk, The Indian Textile Journal, 108: (9)52.
17. Nultsch, W. (1998). Botanique generale. Paris: De Boeck Universite S.A.
18. Oplinger, E.S., Oelke, E.A., Doll, J.D., Bundy, L.G. and Schuler, R.T. (2013). Flax. Alternative Field Crop Manual, 1-11.
19. Pandey, R. and Dayal, R .(2003). FIax-jute and flax-cotton blended fabric. Asian Textile Journal. 11: (7)51-55.
20. Pandey, R. and Dayal, R.(2008). Physico- chemical properties of flax fibre. Textile Industry & Trade Journal, 46: (11-12) 25-28.
21. Pandey, R. and Dayal, R. (2009). Value Addition of Flax (Linum usitatissimum) Fibres. Current Advances in Agricultural Sciences, 1(1): 41-43.