Utilization of *Sesbania aculeate* for Soil Revitalization

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ABSTRACT

The global concern for sustainability and conservation for ecological balance on planet earth had encouraged human to opt green products. The constructive idea regarding the utilization of renewable sources had prompted researchers to explore agricultural waste, under-utilized materials and byproducts as source of fibre for textile industry for the development of technical textiles. The fibre can be obtained from different parts of plants grown for some specific purposes other than fibre extraction.

One such source of textile fibres is the bark of plant used for nitrogen fixation and wind barriers i.e., *dhaincha*. The researches on *dhaincha* have indicated the existence of splendid properties like strength, moisture content, elongation and luster of fibres that are critical for exploring their possibilities in technical textile sector. The utilization of the plant for secondary uses besides the primary use can be taken up as an additional source of income generation among the local people. Hence the study was conducted with the objective to extract fibres from *dhaincha* bast and assessment of fibre properties. The fibres were extracted from bark after 15 days stagnant water retting method. The extracted fibres were then scoured with combination of sodium carbonate and sodium hydroxide and softened with silicon softener. The processed fibres were suitable for the development of nonwoven for technical end uses.

The extracted fibres exhibited properties like 5.43 g/denier tenacity, 3.41 % elongation, 35.3 denier fineness, 8.12% moisture content. The properties improved in scoured and softened fibres. The nonwoven was developed in two thickness and tested as mulch material in agriculture. The results showed effective moisture control through *dhaincha* nonwoven material in comparison to conventional much materials. The fibres were dyed also to explore use in home textile sector and results revealed possibility of functional lifestyle products from coloured *dhaincha* nonwoven material. Thus the use of plant grown for green manuring can be diversified for technical textile sectors.

Keywords: Agricultural waste, *dhaincha*, natural bast fibre, nonwoven and technical textiles, Sesbania aculeate, Soil revitalization, unconventional fibre,

1. INTRODUCTION

The field of technical textiles has accelerated to a huge extent owing to the growing demand of specialized products in domestic as well as global market. The upsurge in demand and production of these fibres has contributed in diminishing natural resources and continuously posed threat to a safe and clean earth environment.

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Increasing public awareness regarding harmful consequences of global weather on human and environment has compelled human being to focus the interest in protection of environment and utilization of resources in sustainable manner.

The constructive idea regarding the exploration and balanced use of natural resources like forestry, agricultural waste and substitution of nonrenewable products has prompted human towards the utilization of natural fibres. Among natural fibres, bast fibres have proved to be potential source of raw material for wide range of traditional and novel product range owing to their physical properties like good mechanical strength, light weight, low cost, etc. Bast fibres possess reasonably distinctive properties, distinct composition and features that are essential for fabric structures like woven, knitted, nonwoven, knotted, grids, membranes and composites.

Agriculture plays a vital role in India's economy. Hence the field of agro textiles have gained importance owing to their demand in agricultural production, storage and transportation. The structures as mats, screen, nets and bags, are used in agriculture sector for protection and revitalize soil texture, moisture regulation and to increase and improve the crop yield and quality. Hence, there is necessity to develop an attitude for production and diversification of naturally available nonconventional fibres subsequently that could encourage the locally people to produce and earn better returns.

One such source of textile fibres is the byproduct of plant used for nitrogen fixation and wind barriers i.e., *dhaincha*. *Dhaincha* is a green manure crop grown prior to paddy cultivation. Botanically the plant is known as *Sesbania aculeata* and popular by common name as *dhaincha*, *danchi*, *dunchi*, *danicha*. The stem of *dhaincha* plant, in most of cases are left to be decomposed on the ground or taken by local people as a source of fuels. The stem possess good amount of fibres that are strong, coarse and shiny. These are obtained from the outer sheath of plant and have potential to be developed as technical textiles. Here an attempt has been made by processing of *dhaincha* fibres for the development of nonwoven fabric for the purpose of mulch material.

2. MATERIALS AND METHODS

The materials and methods used in the study are mentioned and described below:

2.1 Raw Material

The plantation of crop was done in the month of May in a farm at Ramnagar, Uttarakhand. The harvesting of plant, for stalk collection was done in the month of September. The branches, leaves and pods were removed from the fresh *dhaincha* plant and the bark was peeled out from the stems and allowed to dry. The dried bark was used to study the effect of different retting methods on the properties of *dhaincha* fibres.

2.2 Retting

Retting of *sesbania aculeata* was done by water in the month of September at a temperature and relative humidity in range of 30^0C - 37^0C and 75 percent - 85 percent, respectively. The retting of fibre was done both in stagnant and running water for same duration. 50 g each dried ribbons of *dhaincha* were submerged in water filled plastic tubs and in water stream for a period of 15 days and 21 days.

After the completion of retting method, fibres were washed with water to remove slimy matter developed over the upper layer and separated by hand and laid on flat surface for drying in the open air under shade and combed manually using combing brush to open the fibre bundles, and to remove remnant vegetative matter adhered to the surface.

Table 1 Scouring recipe for *dhaincha* (*Sesbania aculeata*) fibres (**Fakin *et al*., 2006)**

S. No	Parameters	Amount
1.	Sodium Carbonate (g/l)	10
2.	Sodium Hydroxide (g/l)	5
3.	Wetting agent (g/l)	1
4.	Time (minutes)	45
5.	Temperature (celsius)	95

2.3 Assessment of physical properties

The properties like fibre yield and moisture content of *dhaincha* fibres were assessed in Department of Clothing and Textiles, College of Home Science, GBPUAT Pantnagar whereas the other properties like tenacity, elongation and fineness were conducted at Pashupati Acrylon Limited, Thakurdwara, Uttar Pradesh. One way ANOVA was applied using statistical software " SPSS 20".

2.4 Processing of retted fibres

The *dhaincha* fibres obtained from retting were harsh, hence required further processing to make them pliable and suitable for further work. Therefore, *dhaincha (Sesbania aculeata)* fibres were scoured with the help of chemical recipe and softened with silicon based industrial softener.

Thereafter, the fibre samples obtained after scouring and softening were again assessed for physical properties to observed the affect of processing. The details of scouring and softening recipe are given in Table 1 and 2 respectively.

2.5 Preparation of non woven

The processed fibres were used for the development of nonwoven fabric. The nonwoven fabric was manufactured at OBEETEE Textiles Limited, SIDCUL, Pantnagar, U. S. Nagar, Uttarakhand. The non woven fabric was prepared on needle punching loom that used Dilo technology of Germany based on Delta card system. Punching was done in scoured and softened fibres to entangle the fibres directly with each other. The nonwoven fabric was prepared in two thickness and assessed for fabric thickness, GSM, tensile strength and elongation.

2.6 Application of nonwoven as mulch material in agriculture

Mulch material helps to make vegetable garden more attractive and results in higher yielding. There are many types of mulch materials like natural and synthetic. So the prepared nonwoven was tested as mulching material against the conventional mulching material. The water retention level in the soil after covering it with definite time interval was assessed. In this experiment, 5 pots were taken with identical soil and moistened with equal amount of water. The soil in three separate pots was covered with three different mulch material namely, poly mulch, wheat straw, thick and thin *dhaincha* nonwoven while one pot was left uncovered that was taken as control sample (Figure 1). The moisture content of soil was calculated after 3 days, 6 days, 9 days and 12 days for each soil sample.

3. RESULT AND DISCUSSION

The physical properties of retted, scoured and softened *Sesbania aculeata* (*dhaincha*) fibre are given in Table 3 and 4.

3.1 Physical properties *Sesbania aculeata* (*dhaincha*) fibres extracted through water retting

3.1.1 Fibre yield

The yield of fibres represents the amount of fibres obtained after the removal of vegetative substances during the process of retting. It can be affirmed from Table 3 that maximum yield of fibres (58.6 %) was obtained in case of fibre extracted from 15 days of stagnant water retting method. This was followed by 21 days stagnant water retting that yielded 53.2 %. This might be due to the removal of noncellulosic matter with duration of retting days that resulted in lower yield. Similar pattern was observed in case of running water retting method, the yield of fibres was lowest after 21 days of retting (48.4%) as compared to yield of fibres after 15 days of running water retting that were found to be 51.4 %. **Martin *et al.* (2013)** and **Pallesen (1996)** also observed that with increased duration of retting of fibers, fibre yield decreased owing to cleaning of fibers and removal of cortical parenchyma and middle lamellae from the stem of plant.

Table 2 Softening recipe for *dhaincha* (*Sesbania aculeata*) fibres **(Zhang and Zhang, 2010)**

S. No	Parameters	Amount
1.	Silicon Softener (%)	4
2.	Time (minutes)	45
3.	Temperature (celsius)	35

3.1.2 Tenacity and elongation

It is clear from Table 3 that, the tenacity of *dhaincha* fibres obtained from water retting decreased slightly with increase in duration of retting. The fibres obtained after 15 days of retting exhibited maximum tenacity (5.43g/denier). This might be owing to the incomplete degradation and non separation of fibres from the bundles resulted in partial removal of lignin thus the higher tenacity revealed was owing to the strength of bundles. **Paridah *et al.* (2009)** also found that fibres extracted from stagnant water biological methods for less duration had higher tenacity. This was followed by fibres extracted after 15 days running water retting (5.11 g/denier) and 21 days stagnant water retting (5.10 g/denier) whereas it was minimum (4.5g/denier) for fibres extracted after the duration of 21 days of running water retting. **Dass *et al.* (2015)** also observed similar effect that with the increase in retting time in days, the strength of the fibres decreased to a minimum and then became constant.

Another important property of fibre that influences and is related to the tenacity is the elongation of the fibres. **Kant and Alagh (2013)**, explained that strength and elongation are inseparably connected to one another. The elongation of *dhaincha* (*Sesbania aculeata*) fibres obtained from stagnant water retting decreased on increase of duration whereas it increased in case of running water retting. The fibres obtained after 21 days running water retting exhibited maximum elongation (3.76 %). **Singh and Rani (2013)** also observed that on increasing the time duration of stagnant water retting, the elongation of *dhaincha* fibre also increased. Minimum elongation (2.62 %) was observed in case of fibres obtained from 21 days of stagnant water retting

3.1.3 Fineness

It can be affirmed from Table 3 that the fineness of fibre decreases with increase in the retting duration. In both the stagnant and running water retting the fibre become finer on increasing the duration from 15 to 21 days. Maximum value of fineness was exhibited by the fibres obtained from 15 days of stagnant retting (35.3 denier) that implied the fibres were coarse. This was followed by fineness value of fibres obtained from 21 days of stagnant water retting. Minimum value of fineness (29.3 denier) was observed in case of fibres obtained from 21 days of running water retting. This might be owing to the presence of higher quantities of lignin in fibres retted for lower duration **(Singh and Rani, 2013)**.

Table 3 Physical properties of fibre retted with water for different duration

S. No.	Retting method	Fibre yield (%)	Tenacity (g/denier)	Elongation (%)	Fineness (denier)	Moisture content (%)
1.	15 days (Stagnant water)	58.6	5.43	3.4	35.3	8.12
2.	21 days (Stagnant water)	53.2	5.10	2.62	34.1	8.24
3.	15 days (Running water)	51.4	5.11	3.14	32	8.61
4.	21 days (Running water)	48.4	4.5	3.76	29.3	8.9

3.1.4 Moisture content

It can be observed from Table 3 that increase in moisture content of *dhaincha* fibres with number of retting days was noticed both in case of stagnant and running water retting. The fibres obtained after 21 days exhibited maximum moisture content (8.9 %) followed fibres from 15 days retting with 8.61% moisture content. Minimum moisture content of 8.12 % was exhibited by fibres extracted from 15 day stagnant water retting. The difference in the moisture content might be due to varible removal of non-absorbing matter like lignin and other non cellulosic natter that get released with the action of microbial growth in retting water. **Lewin (2007)** had also explained that the presence of lignin decreases moisture absorption due to its hydrophobic nature.

The fibre obtained from 15 days of stagnant water retting showed better properties with fibre yield (58.6 %), tenacity (5.43g/denier), elongation (3.4 %), fineness (35.3 denier) and moisture content (8.12 %). Therefore the fibre extracted from 15 days of stagnant water retting was selected for extraction of fibres for further study.

3.2 Physical properties of scoured and softened *Sesbania aculeata* (*dhaincha*) fibres

The 15 days stagnant water retting method was selected for fibre extraction. The properties of scoured and softened fibres were compared with controlled fibres (15 day stagnant water retted fibres) and is given in Table 4. The weight loss of controlled fibres was more (58.6 %) as compared to scoured fibres which was found to be 13.6 %. This might be owing to the removal of excessive vegetative matter during retting (controlled fibres) as compared to scouring process.

Figure 1 Flower pots with different mulch material

of film over fibre surface that contributed to the strength. **Rajadhyaksha and Keskar (2002)** affirmed that industrial softener cross linked with hydroxyl group of cellulose to form an evenly distributed film on the fibre surface, thereby, enhancing tenacity and uniformity of fibres.

The elongation of scoured fibres was more (5.4 %) as compared to retted and softened fibres.

Table 4 Physical properties of control, scoured and softened fibre

S. No.	Retting method	Weightloss (%)	Tenacity (g/denier)	Elongation (%)	Fineness (denier)	Moisture content (%)
1.	Control fibres	58.6	5.43	3.4	35.3	8.12
2.	Scoured fibres	13.6	4.7	5.4	33	8.24
3.	Softened fibres	-	5.21	4.25	33.74	8.01

Similar in case of tenacity the controlled fibres exhibited maximum tenacity (5.43 g/ denier) which decreased after chemical scouring to 4.7 g/denier. This might be due to the removal of the impurities that causes opening of molecular structures that ultimately reduced fibre tensile strength **(Nalankilli *et al.*, 2008)**. **De Rosa *et al.* (2011)** and **Nazire *et al.* (2017)** also reported that the tenacity of okra and banana fibres decreased after alkali treatment. Further it was observed that the tenacity of fibres increased after softening (5.21g/ denier). This may be owing to the formation

The finding are in consonance with results of **Singh and Rani (2013)** who found that the elongation of *dhaincha* (*Sesbania aculeata*) fibres increased from 2.13% to 5.48% after treatment with alkali.

Further it was observed that scoured fibres were finer (33 denier) as compared to retted and softened fibre. This might be owing to the presence of vegetative matter on retted fibres and formation of film over the fibres layer on softened fibres that contributed to higher fineness value. **Wang *et al.* (2009)** also observed

Table 5 Physical properties of nonwoven fabrics

S. No.	Samples	Thickness (mm)	Fabric Weight (GSM) (g/m²)	Tensile strength (Kg)		Elongation (mm)	
				MD	CD	MD	CD
1.	Nonwoven (thin)	6.28	616	5.6	2.4	19	49
2.	Nonwoven (thick)	8.92	1604	6.5	4	21	45

decrease in fineness value of jute fibres after scouring treatment which was due to the removal of lignin located in the cementing layer between the cells.

Similarly the moisture content of scoured fibres was better as compared to controlled and softened fibres. The lower moisture content of retted fibres might be owing to the presence of excessive lignin content whereas the presence of silicon layer had reduced moisture content. **Buschile-Diller *et al.* (1999)** also reported that changes in moisture content with certain treatments were due to changes in crystallinity and pore structureof the fibre polymer.

3.3 Physical properties of nonwoven fabrics

The processed *Sesbania aculeata* (*dhaincha*) fibres was used to prepared nonwoven of two thickness and the properties were assessed and given in Table 5. The thickness of thin nonwoven was found to be 6.28 mm with GSM of 616 g/m². The tensile strength in Machine Direction (MD) was observed to be 5.6 kg with elongation of 19 mm whereas tensile strength in Cross Direction (CD) was found to be 2.4 kg with 49 mm of elongation.

The properties of thick nonwoven was found to be better as compared to thin *dhaincha* nonwoven. the thickness was found to be 8.92mm and fabric weight of 16.4 g/m². The tensile strength of thick nonwoven in Machine Direction (MD) was observed to be 6.5 kg with elongation of 21 mm whereas tensile strength in Cross Direction (CD) was 4 kg with 45 mm of elongation. The fibres in thick nonwoven were more compact and entangled properly as compared to thin nonwoven. This resulted in better physical properties.

3.4 Suitability assessment of prepared nonwoven fabric as mulching

The suitability of prepared *Sesbania aculeata* (*dhaincha*) nonwoven fabrics of different thickness for mulch material was tested by comparing it with control and other conventional mulch material i.e., wheat straw and poly mulch. The different material were tested for water retention ability and the reading are given in Table 6.

Table 6 Moisture content of soil covered with different mulch material for different duration

Treatment	Moisture content (%) recorded for different duration			
	3 days	6 days	9 days	12 days
Control (without cover)	5.79	3.27	2.44	1.17
Poly mulch	10.35	8.81	6.38	5.34
Straw mulch	8.62	7.85	6.61	4.73
Nonwoven (thin)	12.5	10.29	7.16	6.10
Nonwoven (thick)	15.02	13.95	11.26	9.06

It is clear from the Table 6 that moisture per cent was highest in the soil covered with

thick *Sesbania aculeata* (*dhaincha*) nonwoven material followed by moisture of soil covered with thin *Sesbania aculeata* (*dhaincha*) nonwoven material and poly mulch. The moisture per cent was found to be lowest in the soil without covering (control). This may be due to the fact that nonwoven fabric fully covered the soil that resulted in less water loss as compared
to other material.

The moisture percent in soil covered with thick *Sesbania aculeata* (*dhaincha*) nonwoven material was 15.02 %, 13.95 %, 11.26 % and 9.06 % which was higher than thin *Sesbania aculeata* (*dhaincha*) nonwoven material that showed moisture percent of 12.5 %, 10.29 %, 7.16 and 6.10 % after 3 days, 6 days, 9 days and 12 days respectively. This may be owing to the capacity of thick nonwoven material to retain more water and to minimize the
evaporation of water.

CONCLUSION

Sesbania aculeata (*dhaincha*) can be a promising underutilized agricultural resource for revitalizing the Soil properties and could be extensively useful in technical textile sector. The constructive idea regarding the exploration and balanced use of natural resources has prompted human towards the utilization of underutilized fibres like *dhaincha*. For this reason, there is need to search for the extraction methods to remove the non-fibrous components to completely free the bast fibres from other impurities. Out of the two retting methods, 15 days stagnant retting method yielded better properties fibres in term of strength and fineness. The scouring and softening process contributed in enhancing the physical properties of fibres. The nonwoven fabric prepared from processed fibre was found suitable as mulch material in comparison to control and other conventional mulch material like wheat straw and poly mulch. Finally it can be stated that *Sesbania aculeata* (*dhaincha*) fibres can be explored as a potential source that could be used for numerous end uses in agriculture sector and other technical textile sector.

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