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Cotton Plant Stalks: A Valuable Industrial Raw Material

Dr Sujata Saxena, Principal Scientist & Head, Chemical and Biochemical Processing Division at ICAR-CIRCOT, Mumbai has more than 36 years of research experience and has also held the charge of the Director (Acting) of the institute. She has handled about 30 research projects, published more than 70 scientific papers, articles and book chapters, has been granted one patent and has presented more than 30 research papers at

**EXPERT'S
Column**



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She has been awarded the Honorary Fellowship of the Textile Association of India, Mumbai. She is a member of the Textile Division Council of the BIS and ISO Sectional Committee on Textiles (TC 38) and a senior member of the American Association of Textile Chemists and Colorists and member of the Professional Awards Committee of the Textile Association of India.

The cotton stalk is the biomass left in the field after the harvesting of cotton. The production of cotton stalk per hectare of cotton crop depends on the variety, plant type, growing conditions (rainfed or irrigated), soil type and agroclimatic factors etc. but on an average, about 3 tonnes of stalks per hectare are produced in our country. Based on current area under cotton cultivation, about 35-40 million tonnes cotton stalks per year are available in the country. Most of the stalk produced is treated as waste and burnt off in the fields with only a part of it used as fuel by rural masses. Cotton stalk is a lignocellulosic material and contains 67.3 to 70.0% holocellulose, 24.3 to 28.2% lignin and 5.9 to 8.3% ash.

In contrast to other agricultural crop residues, it is comparable to the hardwood in respect of fibrous structure and hence it can be used for the manufacture of various value-added products such as particle board, hard board, soft board, kraft and writing grade paper, corrugated boxes, etc. Besides it can also be used for energy generation by converting into briquettes and pellets. ICAR-CIRCOT has carried out detailed research on utilisation of this raw material for the manufacture of various industrial products which on one hand can save the environmental pollution caused by burning of the leftover stalks in cotton fields and on the other can provide additional income to the farmers through sale

of stalks and can help in development of rural entrepreneurship through establishment of supply chain and cotton stalks based industries and. A brief description of various products which can be made from the cotton stalks has been provided in this article.

Particle Board

CIRCOT has standardised the process of preparation of three layered particle boards from cotton plant stalks. It involves chipping of stalks, mixing of chips with synthetic binders such as urea / phenol formaldehyde, preparation of the mat and finally, pressing between the heated platens of a hydraulic press for specific time and pressure. The prepared boards are then cooled to attain dimensional stability and cut to the desired size. These meet the BIS specifications and by using different chemicals and additives, can be made water proof, fire proof, termite resistant, etc. and are suitable for interior decoration, false ceiling, partitioning, panelling etc. Due to the lower cost of raw material and lesser power requirements for its conversion into the finished product, the cost of particle board made from cotton stalk is much lower than that made from wood. Institute has installed a one tonne per day capacity pilot plant using the developed technology at its Ginning Training Centre (GTC) located at Nagpur for demonstration purposes with funding from CFC, Netherlands.

Hardboard

The process of preparation of Hardboards (binderless boards) comprises of chipping of stalks which are steamed at high pressure for 2 min in a thermo-mechanical pulper to get thermo-mechanical pulp followed by mat formation and pressing in a steam- heated hydraulic press. Various process parameters were standardised through a series of laboratory trials and large-scale trials was conducted at an industrial unit in Sangli. Good quality binderless boards were prepared from 100% cotton stalks and blends of cotton stalk with bagasse pulps blended in the 1:1 ratio. These boards had much higher mechanical strength than the BIS norm with 100% cotton stalks boards being better. Water absorption was however slightly higher due to the presence of bark covering on cotton stalk.

Soft Board

Soft boards are generally made using thermo-mechanical pulp from bagasse and wood pulp

together. Since cotton stalk produced good quality thermo-mechanical pulp, it was used to make soft boards. Trials were undertaken at a mill in Aurangabad where thermo-mechanical pulp of cotton stalk was blended with bagasse pulp in 20:80 ratio and soft boards of 11 mm, 16 mm and 25 mm thicknesses were made. The boards were of good quality as evidenced by the MOR value of 22 kg/cm² which was better than that of 100% bagasse boards (18 kg/cm²). The study indicated that depending upon the requirement of MOR, cotton stalks could be blended with bagasse to produce soft boards of desired quality. These boards find application as insulating material.

Kraft Paper and Corrugated Boxes

Cotton stalk chips were first digested with kraft liquor followed by beating/refining to get Kraft pulp of desired CSF freeness. Total pulp yield was good (~66%). Kraft paper of 100 g/m² was prepared from this pulp and taken up for corrugation trials in a local factory. Corrugated fibre boards of 5 ply were prepared and converted to telescopic type Polypropylene (PP) laminated and non-laminated CFB boxes. Both type of corrugated boxes made from cotton stalks could meet all the strength properties specified by the Bureau of Indian Standards and were found superior to the CFB boxes made from commercial kraft paper. Lamination was found to improve the strength properties of the CFB boxes made from Cotton plant stalks

Simulated laboratory trials indicated the suitability of these boxes for packaging and transportation of fruits. Actual packaging, transportation and storage trials revealed these CFB boxes to be a technically viable alternative to conventional wooden boxes which will



Cotton stalk chips

contribute towards easing the pressure on the forest based raw materials for packaging of horticultural produce.

Energy Applications

As cotton stalks have good calorific value, these can be used for energy generation by converting into pellets and briquettes. Process parameters for preparation of pellets and briquettes from cotton stalks such as particle size and moisture content were optimised in a commercial pelleting and briquetting plant. Pellets thus made were found to have 5800 kg/m² Bulk Density (BD) and 3800 kcal/kg High Heating Value (HHV) with 7.4% ash content. These can be used as fuel in domestic and industrial applications. A pelleting system of 150 kg/h capacity for conversion of cotton stalks and other biomass into 6, 8 and 10 mm diameter pellets has been commissioned at GTC, Nagpur, which is being used for demonstrations to farmers and budding entrepreneurs.

Cotton stalk pellets can also be used for co-firing in thermal power plants to generate electricity and improving their environmental footprints. GOI had issued an advisory in November 2017 wherein use of 5-10% biomass pellets along with coal has been recommended for co-firing in thermal power plants and a National Mission has been set up to study and provide solutions to the various related issues. ICAR- CIRCOT has been sanctioned a project worth Rs 5.15 crores by this Mission to study various issues. Torrefaction of biomass wherein the biomass is heated to a temperature ranging from 200-350 degree centigrade in limited quantity of air to make it hydrophobic, more energy dense with better grindability enabling use of higher quantities for co- firing is also



Cotton stalk pellets

being attempted in the project. A demonstration biomass torrefaction plant is also proposed to be designed and commissioned under the project.

Constraints and Solutions

A primary constraint in the industrial utilisation of cotton stalks is the lack of an established supply chain. The costs associated with their collection and transportation, and limited availability during specific periods of the year (mainly from January to March in Maharashtra) hinders their utilisation. To address the supply chain challenges, viable methods for cotton stalk collection and supply have been proposed by the institute. Manual uprooting and collection, along with tractor-operated V-pass uprooting and manual collection, offer practical solutions. Chipping the cotton stalks using tractor-driven equipment and simultaneously loading the material onto mini trucks can significantly reduce transportation costs.

Assuming that the farmer is paid Rs. 1000/tonne stalk, chipped stalks can be made available at a cost of Rs. 2700-3000 per tonne at the factory gate within a distance of 50 km. To enhance the cotton stalk supply chain, entrepreneurs can provide V-Pass equipment and mobile shredders to farmers or local agents for collection and supply. Since cotton stalk collection is a seasonal activity, renting tractors and trolleys becomes a practical solution. A shredder and V-pass typically cost around Rs. 2.0 lakh, and one shredder can supply about 1000 tonnes in a month sufficient for a 40TPD plant.

Conclusion

Thus it is seen that the cotton stalks considered to be waste and disposed of by burning in the fields resulting in environmental pollution can find varied industrial application by creating awareness and addressing the supply chain issues. This would not only result in cleaner air but would also fetch additional income to the farmers and lead to entrepreneurship and employment opportunities. The industrial products made from these stalks also have the potential to further preserve the environment by reducing our dependence on scarce resources like wood and fossil fuel like coal.

Courtesy : Cotton India 2023-24

(The views expressed in this column are of the author and not that of Cotton Association of India)

Sr. No.	Parameters	Grade				Staple				Micronaire	
		Premium		Discounts		Premium		Discounts		Micronaire	Discount
		Grade	Premium Amount	Grade	Discount Amount	Staple	Premium Amount	Staple	Discount Amount		
8	P/H/R (U)	Superfine	+1400	Fully Good	-1300			26	-1000	3.0 - 3.2	-800
	ICS-105										
	(Staple length 27mm)		(+2.14)		(-1.99)				(-1.53)		(-1.22)
	Micronaire 3.5 - 4.9	Extra S. Fine	N.A.	Good	-1600					3.3 - 3.4	-400
	(Grade : Fine) Trash - 4% Strength/GPT 26				(-2.45)						(-0.61)
9	M/M(P)/SA/TL/G ICS-105	Superfine	N.A.	Fully Good	-800	28	+1400			2.7 - 2.9	-500
	(Staple length 27mm)										
	Micronaire 3.0 - 3.4				(-1.22)		(+2.14)				(-0.77)
	(Grade: Fine)	Extra S. Fine	N.A.	Good	-1000						
	Trash - 4% Strength/GPT 25				(-1.53)						
10	M/M(P)/SA/TL	Superfine	+1000	Fully Good	-1200						
	ICS-105										
	(Staple length 27mm)		(+1.53)		(-1.84)						
	Micronaire 3.5 - 4.9	Extra S. Fine	N.A.	Good	-1400						
	(Grade:Fine) Trash - 3.5% Strength/GPT 26				(-2.14)						
11	P/H/R (U)	Superfine	+1400	Fully Good	-1300	29	N.A.			3.0 - 3.2	-800
	ICS-105										
	(Staple length 28mm)		(+2.14)		(-1.99)						(-1.22)
	Micronaire 3.5 - 4.9	Extra S. Fine	N.A.	Good	-1600					3.3 - 3.4	-400
	(Grade:Fine)				(-2.45)						(-0.61)
	Trash - 4% Strength/GPT 27										
12	M/M(P)	Superfine	+1100	Fully Good	-1000					3.0 - 3.2	-1200
	ICS-105										
	(Staple length 28mm)		(+1.68)		(-1.53)						(-1.84)
	Micronaire 3.7 - 4.5	Extra S. Fine	N.A.	Good	-1300 (-1.99)					3.3 - 3.4	-800 (-1.22)
	(Grade:Fine) Trash - 3.5% Strength/GPT 27								3.5 - 3.6	-400 (-0.61)	
13	SA/TL/K	Superfine	+1100	Fully Good	-1000					3.0 - 3.2	-1200
	ICS-105										
	(Staple length 28mm)		(+1.68)		(-1.53)						(-1.84)
	Micronaire 3.7 - 4.5	Extra S. Fine	N.A.	Good	-1300 (-1.99)					3.3 - 3.4	-800 (-1.22)
	(Grade:Fine) Trash - 3.5% Strength/GPT 27								3.5 - 3.6	-400 (-0.61)	
14	GUJ	Superfine	+1100	Fully Good	-1000			27	-1500	3.0 - 3.2	-1200
	ICS-105										
	(Staple length 28mm)		(+1.68)		(-1.53)				(-2.30)		(-1.84)
	Micronaire 3.7 - 4.5	Extra S. Fine	N.A.	Good	-1300 (-1.99)					3.3 - 3.4	-800 (-1.22)
	(Grade:Fine)										
	Trash - 3% Strength/GPT 27								3.5 - 3.6	-400 (-0.61)	
15	R (L)	Superfine	+1100	Fully Good	-1200			28	-1400	3.0 - 3.2	-1200
	ICS-105										
	(Staple length 29mm)		(+1.68)		(-1.84)				(-2.14)		(-1.84)
	Micronaire 3.7 - 4.5	Extra S. Fine	N.A.	Good	-1400					3.3 - 3.4	-800 (-1.22)
	(Grade:Fine)										
	Trash - 3.5% Strength/GPT 28				(-2.14)					3.5 - 3.6	-400 (-0.61)

Sr. No.	Parameters	Grade				Staple				Micronaire	
		Premium		Discounts		Premium		Discounts		Micronaire	Discount
		Grade	Premium Amount	Grade	Discount Amount	Staple	Premium Amount	Staple	Discount Amount		
16	M/M(P)	Superfine	+800	Fully Good	-800					3.0 - 3.2	-1200
	ICS-105										
	(Staple length 29mm)										
	Micronaire 3.7 - 4.5	Extra S. Fine	+1100	Good	-1100					3.3 - 3.4	-800 (-1.22)
	(Grade:Fine)										
Trash-3.5%Strength/GPT28	(+1.68)	(-1.68)	-400 (-0.61)								
17	SA/TL/K	Superfine	+800	Fully Good	-800					3.0 - 3.2	-1200
	ICS-105										
	(Staple length 29mm)										
	Micronaire 3.7 - 4.5	Extra S. Fine	+1100	Good	-1100					3.3 - 3.4	-800 (-1.22)
	(Grade:Fine)										
Trash - 3% Strength/GPT 28									3.5 - 3.6	-400 (-0.61)	
18	GUJ	Superfine	+800	Fully Good	-800	30	+1200			3.0 - 3.2	-1200
	ICS-105										
	(Staple length 29mm)										
	Micronaire 3.7 - 4.5	Extra S. Fine	+1100	Good	-1100					3.3 - 3.4	-800 (-1.22)
	(Grade:Fine)										
Trash - 3% Strength/GPT 28									3.5 - 3.6	-400 (-0.61)	
19	M/M(P)	Superfine	+900	Fully Good	-900					3.0 - 3.2	-1200
	ICS-105										
	(Staple length 30mm)										
	Micronaire 3.7 - 4.5	Extra S. Fine	+1200	Good	-1100					3.3 - 3.4	-800 (-1.22)
	(Grade:Fine)										
Trash-3.5%Strength/GPT29	(1.84)	(-1.68)	-400 (-0.61)								
20	SA/TL/K/O	Superfine	+900	Fully Good	-800					3.0 - 3.2	-1200
	ICS-105										
	(Staple length 30mm)										
	Micronaire 3.7 - 4.5	Extra S. Fine	+1200	Good	-1000					3.3 - 3.4	-800 (-1.22)
	(Grade:Fine)										
Trash - 3% Strength/GPT 29	(+1.84)	(-1.53)	-400 (-0.61)								
21	M/M(P)	Superfine	+700	Fully Good	-1000					3.0 - 3.2	-1200
	ICS-105										
	(Staple length 31mm)										
	Micronaire 3.7 - 4.5	Extra S. Fine	+1000	Good	-1200					3.3 - 3.4	-800 (-1.22)
	(Grade : Fine) Trash - 3% Strength/GPT 30										
22	SA/TL/K/IN/O	Superfine	+700	Fully Good	-1000					3.0 - 3.2	-1200
	ICS-105										
	(Staple length 31mm)										
	Micronaire 3.7 - 4.5	Extra S. Fine	+1000	Good	-1200					3.3 - 3.4	-800 (-1.22)
	(Grade : Fine) Trash - 3% Strength/GPT 30										

Sr. No.	Parameters	Grade				Staple				Micronaire	
		Premium		Discounts		Premium		Discounts		Micronaire	Discount
		Grade	Premium Amount	Grade	Discount Amount	Staple	Premium Amount	Staple	Discount Amount		
23	SA/TL/K/TN/O	Superfine	N.A.	Fully Good	N.A.			31	N.A.	3.0 - 3.2	N.A.
	ICS-106										
	(Staple length 32mm)										
	Micronaire 3.5 - 4.2	Extra S. Fine	N.A.	Good	N.A.					3.3 - 3.4	N.A.
	(Grade : Fine) Trash - 3% Strength/GPT 31										
24	M/M(P)	Superfine	+1500	Fully Good	-1000	35	+2000	33	-3000	2.5 - 2.7	-700
	ICS-107										
	(Staple length 34mm)		(+2.30)		(-1.53)		(+3.06)		(-4.59)		(-1.07)
	Micronaire 2.8 - 3.7	Extra S. Fine	N.A.	Good	-1500	36	+3500				
	(Grade : Fine) Trash - 4% Strength/GPT 33				(-2.30)	(+5.36)					
25	K/TN	Superfine	+2000	Fully Good	-1000	35	+2000	33	-4000	2.5 - 2.7	-700
	ICS-107										
	(Staple length 34mm)		(+3.06)		(-1.53)		(+3.06)		(-6.12)		(-1.07)
	Micronaire 2.8 - 3.7	Extra S. Fine	N.A.	Good	-1500	36	+3500				
	(Grade : Fine) Trash - 3.5% Strength/GPT 34				(-2.30)	(+5.36)					
26	M/M(P)	Superfine	+1500	Fully Good	-1000	36	+1500	34	-2000	2.5 - 2.7	-700
	ICS-107										
	(Staple length 35mm)		(+2.30)		(-1.53)		(+2.30)		(-3.06)		(-1.07)
	Micronaire 2.8 - 3.7	Extra S. Fine	N.A.	Good	-1500						
	(Grade : Fine) Trash - 4% Strength/GPT 35				(-2.30)						
27	K/TN	Superfine	+2000	Fully Good	-1000	36	+1500	34	-2000	2.5 - 2.7	-700
	ICS-107										
	(Staple length 35mm)		(3.06)		(-1.53)		(+2.30)		(3.06)		(-1.07)
	Micronaire 2.8 - 3.7	Extra S. Fine	N.A.	Good	-1500						
	(Grade : Fine) Trash - 3.5% Strength/GPT 35				(-2.30)						

Conversion factor – 653.54 based on the RBI closing exchange rate of 1 US \$ = Rs.83.36 prevailing on 29th May 2024.

Figures in bracket denotes value difference in Cents per Lb.

Note :

- (1) These Value Differences are applicable to domestic trade.
- (2) The above differences are merely indicative in nature. Cotton Association of India gives no warranty as to the accuracy or completeness of information contained herein and accepts no legal responsibility howsoever arising in relation to such information.
- (3) Premium and Discount mentioned in Indian Rupees above will remain constant for one month whereas the same mentioned in Cents per Lb. will vary as per the exchange rate fixed by the Reserve Bank of India.

UPCOUNTRY SPOT RATES								(Rs./Qtl)					
Standard Descriptions with Basic Grade & Staple in Millimetres based on Upper Half Mean Length [By law 66 (A) (a) (4)]								Spot Rate (Upcountry) 2023-24 Crop June 2024					
Sr. No.	Growth	Grade Standard	Grade	Staple	Micronaire	Gravimetric Trash	Strength /GPT	3rd	4th	5th	6th	7th	8th
1	P/H/R	ICS-101	Fine	Below 22mm	5.0 – 7.0	4%	15	12485 (44400)	12457 (44300)	12457 (44300)	12457 (44300)	12570 (44700)	12738 (45300)
2	P/H/R (SG)	ICS-201	Fine	Below 22mm	5.0 – 7.0	4.5%	15	12654 (45000)	12626 (44900)	12626 (44900)	12626 (44900)	12738 (45300)	12907 (45900)
3	GUJ	ICS-102	Fine	22mm	4.0 – 6.0	13%	20	10826 (38500)	10770 (38300)	10826 (38500)	10854 (38600)	10854 (38600)	10882 (38700)
4	KAR	ICS-103	Fine	22mm	4.5 – 6.0	6%	21	12373 (44000)	12373 (44000)	12373 (44000)	12373 (44000)	12373 (44000)	12373 (44000)
5	M/M (P)	ICS-104	Fine	23mm	4.5 – 7.0	4%	22	14482 (51500)	14397 (51200)	14397 (51200)	14397 (51200)	14397 (51200)	14397 (51200)
6	P/H/R(U) (SG)	ICS-202	Fine	27mm	3.5 – 4.9	4.5%	26	14904 (53000)	14875 (52900)	14875 (52900)	14932 (53100)	14988 (53300)	14988 (53300)
7	M/M(P)/SA/TL	ICS-105	Fine	26mm	3.0 – 3.4	4%	25	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)
8	P/H/R(U)	ICS-105	Fine	27mm	3.5 – 4.9	4%	26	15044 (53500)	15016 (53400)	15016 (53400)	15072 (53600)	15157 (53900)	15157 (53900)
9	M/M(P)/SA/TL/G	ICS-105	Fine	27mm	3.0 – 3.4	4%	25	14510 (51600)	14482 (51500)	14482 (51500)	14482 (51500)	14482 (51500)	14482 (51500)
10	M/M(P)/SA/TL	ICS-105	Fine	27mm	3.5 – 4.9	3.5%	26	15241 (54200)	15213 (54100)	15213 (54100)	15213 (54100)	15213 (54100)	15213 (54100)
11	P/H/R(U)	ICS-105	Fine	28mm	3.5 – 4.9	4%	27	15297 (54400)	15269 (54300)	15269 (54300)	15325 (54500)	15410 (54800)	15410 (54800)
12	M/M(P)	ICS-105	Fine	28mm	3.7 – 4.5	3.5%	27	15494 (55100)	15466 (55000)	15466 (55000)	15466 (55000)	15494 (55100)	15494 (55100)
13	SA/TL/K	ICS-105	Fine	28mm	3.7 – 4.5	3.5%	27	15550 (55300)	15522 (55200)	15522 (55200)	15522 (55200)	15550 (55300)	15550 (55300)
14	GUJ	ICS-105	Fine	28mm	3.7 – 4.5	3%	27	15550 (55300)	15522 (55200)	15494 (55100)	15522 (55200)	15550 (55300)	15522 (55200)
15	R(L)	ICS-105	Fine	29mm	3.7 – 4.5	3.5%	28	15916 (56600)	15888 (56500)	15888 (56500)	15916 (56600)	15944 (56700)	15944 (56700)
16	M/M(P)	ICS-105	Fine	29mm	3.7 – 4.5	3.5%	28	15832 (56300)	15803 (56200)	15803 (56200)	15803 (56200)	15832 (56300)	15832 (56300)
17	SA/TL/K	ICS-105	Fine	29mm	3.7 – 4.5	3%	28	15916 (56600)	15888 (56500)	15888 (56500)	15888 (56500)	15916 (56600)	15916 (56600)
18	GUJ	ICS-105	Fine	29mm	3.7 – 4.5	3%	28	15832 (56300)	15803 (56200)	15775 (56100)	15803 (56200)	15832 (56300)	15803 (56200)
19	M/M(P)	ICS-105	Fine	30mm	3.7 – 4.5	3.5%	29	16169 (57500)	16141 (57400)	16085 (57200)	16113 (57300)	16141 (57400)	16141 (57400)
20	SA/TL/K/O	ICS-105	Fine	30mm	3.7 – 4.5	3%	29	16197 (57600)	16169 (57500)	16113 (57300)	16141 (57400)	16169 (57500)	16169 (57500)
21	M/M(P)	ICS-105	Fine	31mm	3.7 – 4.5	3%	30	16563 (58900)	16535 (58800)	16478 (58600)	16478 (58600)	16478 (58600)	16478 (58600)
22	SA/TL/K / TN/O	ICS-105	Fine	31mm	3.7 – 4.5	3%	30	16591 (59000)	16563 (58900)	16563 (58900)	16535 (58800)	16535 (58800)	16535 (58800)
23	SA/TL/K/TN/O	ICS-106	Fine	32mm	3.5 – 4.2	3%	31	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)
24	M/M(P)	ICS-107	Fine	34mm	2.8 - 3.7	4%	33	22637 (80500)	22637 (80500)	22637 (80500)	22777 (81000)	22777 (81000)	22777 (81000)
25	K/TN	ICS-107	Fine	34mm	2.8 - 3.7	3.5%	34	23480 (83500)	23480 (83500)	23480 (83500)	23621 (84000)	23621 (84000)	23621 (84000)
26	M/M(P)	ICS-107	Fine	35mm	2.8 - 3.7	4%	35	23199 (82500)	23199 (82500)	23199 (82500)	23199 (82500)	23199 (82500)	23199 (82500)
27	K/TN	ICS-107	Fine	35mm	2.8 - 3.7	3.5%	35	24043 (85500)	24043 (85500)	24043 (85500)	24183 (86000)	24183 (86000)	24183 (86000)

(Note: Figures in bracket indicate prices in Rs./Candy)