Technical Mission Report

15 05 2003 to 31 05 2003

Availability of cotton stalks for industrial board production in India

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Commissioned by CFC

Dr. Jan E.G. van Dam

ATO B.V.
Agrotechnological Research Institute
Bornsesteeg 59
P.O. Box 17
6700 AA Wageningen
The Netherlands
Tel: +31.0317.475024
Fax: +31.317.475347

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1 Introduction

Cotton is one of the major cash crops for Indian farmers. India is the largest cotton growing country of the world by area, however, the cotton yield per ha are among the lowest in the world because of dry land conditions and dependence on rains. Cotton occupies 5% of the cropped area. With the low yields and high production costs, due to increasing high costs for crop protection, major constraints for economic production is encountered by cotton growers. There is an urgent need to find solutions to increase the returns from cotton farming.

At CIRCOT, The Central Institute for Research on Cotton Technology of the Indian Council of Agricultural Research (ICAR) a number of research and development projects have been conducted in the past years to find additional value for the residues obtained from cotton production. The utilisation of cotton stalks has been explored as raw material for industrial conversion into paper pulps and board materials. The various technologies have been developed on laboratory scales and especially the board production from cotton stalks show good perspective for commercialisation. A detailed project proposal entitled "Utilisation of cotton by-produce for value-added products" has been prepared by CIRCOT for obtaining financial support from the Common Fund for Commodities (CFC), Amsterdam, The Netherlands, to address the aspects of raw materials supplies and up-scaling and technology transfer.

The combination of increased income for cotton farmers, the development of rural industries, with the positive ecological aspects of the use cotton stalks as a renewable resource are major objectives and form a strong socio-economic basis for the project. These aspects of sustainability are considered the major advantages for the use of this agro-residue as wood substitute material in building and construction and furniture, combating the depletion of forest resources, that is of high relevance to the Indian situation, but also for many other cotton growing areas.
In a previous session of the Common Fund's Consultative Committee, considering the proposal, it was recommended that the availability and quality of cotton stalk raw material should be surveyed for primary processing into chips and supply to board manufacturing plants.
In this report the findings are given of a two weeks mission to India, commissioned by CFC to assess the current situation in the various cotton growing zones of India. The results were presented at a workshop on "Utilisation of cotton plant by produce for value added products", held at CIRCOT in Mumbai on 26-27 May 20003.

2 Summary/Main findings as presented at Workshop on utilisation of cotton plant by-produce for value addes products held at CIRCOT in Mumbai on 26-27 May 2003

Based upon observations made at visits to the CIRCOT premises and different cotton growing zones in India and based upon discussions with CIRCOT experts, interviews with local farmers and entrepreneurs, it was concluded that:

- Large amounts of cotton stalks are available in India as residue from cotton farming, which could be made available for fibre board manufacturing. A rough, though conservative estimation is made that up to 10 million tons of dry weight cleaned chips per year could find commercial application. If all material would be consumed for board making, this would correspond to as many as 350 plants of 100 tons / day capacity.

- The farmers, and especially the larger stakeholders, are ready to supply cotton stalks at a competing price, since currently they do not receive any financial returns. Apart from local use as fuel no value addition takes place. Small farmers (< 1ha) are less inclined to give up their fuel source, or want to dispose only of their surplus biomass. Currently seed cotton yield per hectare in India is around 1000 kg, which generates an income of 15.000 to 25.000 Rs per hectare for the farmer (= 300 to 500 $). An additional income for primary cotton producers was estimated to amount approximately 5%.

- Keen interest of board manufacturers could be observed for a cheap alternative raw material, if supplies of sufficient quantities of good quality cotton stalk chips can be ascertained. The quality of cotton stalks, as raw material for board making is considered sufficient after pre-processing and cleaning. The best practice for pre-processing and supplies need investigation.

- In order to organise the supply chain for cotton stalks co-operative societies or collection centres could be set up in the cotton growing areas for collection, storage and pre-processing of cotton stalk. Reduction of the bulk volume of the stalks by chipping will be required if distances for transportation to the factory gate become longer. An additional rural activity would emerge from this.

- Various models of supplies of cotton stalks should be examined varying from chipping at the farm and direct delivery to the factory to organised collection, transport and storage for conversion at pre-processing plants for chipping and cleaning.

- Research on up-scaling of pre-cleaning and raw material demands for optimal board production will be required for successful implementation in board manufacturing industries.

- Demonstration of economic feasibility of the whole supply and production chain for cotton stalk based board manufacturing requires data collection on logistics and techno-economic efficiency of board production processes.

- For the whole exercise it is essential that the economy of scale is addressed, which will identify the suitable production scale for the Indian situation, with respect to logistics and investments. Currently operating particle board plants in India generally do not exceed 60 tons/day capacity. Therefore it is essential that local machine manufacturers are involved, rather than investing in expensive fully automated imported equipment, which will enhance the efficiency, but will not provide much perspective for job creation

- Opportunities to enter into the existing market of particle boards by production of blends of cotton stalks with other lignocellulosic particles (bagasse, wood chips, rice straw) is recommended.

- It is recommended that close and active involvement of the private sector is obtained, both the existing board manufacturers and equipment suppliers, but also potential investors for setting up new production facilities for board manufacturing in rural cotton growing areas.

3 Meetings, itinary and sources

- 18 05 2003 Amsterdam – Zürich – Mumbai

- 19 05 2003 Visit CIRCOT, Mumbai: meeting and discussions with Dr S. Sreenivasan, director CIRCOT, Dr. R. H. Balasubramanya, Head Chemical & Biochemical Processing Division and Principal Scientists, Mr. R. M. Gurjar, Dr. K.M. Paralikar, Dr. A. J. Shaikh and Dr. P. V. Varadarajan.

- Departure for Goa – Dharwad – Hubli, Karnataka, accompanied by Dr. R. H. Balasubramanya

- 20 05 2003 Visit to different farming communities in the proximity of Dharwad; discussions and interviews with cotton growers; visit to University of Agricultural Sciences, Dharwad, meeting with various scientists involved in various aspects of cotton research; meeting and discussions with Dr S.A. Patil, vice-chancellor, Dr J.H. Kulkarni and Dr S.B. Patil;

- 21 05 2003 Departure for Goa – Mumbai

- 22 05 2003 Departure for Delhi – Sirsa, Haryana, accompanied by Mr R.M. Gurjar

- Reception at the Regional station of CIRCOT at Sirsa, meeting with Dr D Monga, head CICR and principal scientists R. Parkash, J. Singh; visit to local farmers and inspection of cotton growing in the fields.

- 23 05 2003 Meeting with scientists at CIRCOT regional station Sirsa, and discussions with invited farmers.

- Departure for Delhi – Mumbai; in Hisar short visist to Haryana Agricultural University, receiving the results of inquiries at local farming communities.

- 24 05 2003 Departure for Nagpur, Maharashtra, accompanied by Dr S. Sreenivasan, Dr. K.M. Paralikar, Dr. A. J. Shaikh and Mr Sietse van der Werff, Common Fund for Commodities; meeting with Dr C.D. Mayee, director CIRC, Nagpur and the scientific staff; visit to particle board plant Aurobindo Laminations Ltd, meeting with Mr Ajay Khati and Mr R.N. Konar; meeting with Mr M.K. Sharma, Bajaj Steel Industries, supplier of cotton processing equipment, excursion to Bajaj Plastics Ltd production plant. Excursion in the premises of CIRCOT Ginning training Centre, Nagpur. Return to Mumbai.

- 25 05 2003 Preparation for workshop

- 26 / 27 05 2003 "International Workshop on Utilisation of Cotton Plant By-produce for Value added Products"; presentation of findings; discussions with many participants and representatives from several Institutions, entrepreneurs and government officials.

- 28 – 30 05 2003 Elaboration of revised proposal with CIRCOT staff

- 31 05 2003 return Mumbai – Zürich – Amsterdam

4 Assesment of the availability of cotton stalks and quality of raw materials for board making

4.1 Primary production of cotton in India

Cotton is grown in all parts of India from north to south under different climatic and soil conditions. As much as 5% of the cropped area is occupied with cotton and is a most important cash crop for Indian farmers. The current total area under cotton cultivation is approximately 8.5 million hectares. Cotton is a seasonal crop and is grown under rain fed conditions in Southern and Central zones (65%). Failure of monsoon and climatic variation may result in crop failure which can jeopardise the availability of cotton stalks to the industry. About 35% of cotton in India is grown under irrigation, especially in the Northern zone, where variable climatic conditions are less critical for a successful crop. In table 1 the main cotton production areas in India are given.

Table 1 - State-wise area under cotton cultivation, production and availability of cotton stalks over the season 1999-2000 (data CIRCOT)

	States	Area (M. ha)	Production (M. bales)*	Availability of stalks (M. tons)
Northern Zone	Haryana	0.546 (6.3%)	1.065	2.780
	Punjab	0.475 (5.4%)	0.785	2.375
	Rajesthan	0.583 (6.7%)	1.300	1.649
Central Zone	Gujarat	1.539 (17.6%)	2.750	4.510
	Madhya Pradesh	0.525 (6.0%)	1.550	1.175
	Maharashtra	3.254 (37.3%)	3.800	8.377
Southern Zone	Andhra Pradesh	1.039 (11.9%)	2.250	3.117
	Karnataka	0.540 (6.2%)	0.700	1.620
	Tamil Nadu	0.185 (2.1%)	0.550	0.455
	Others	0.045 (0.5%)	0.150	0.135
	Total	8.731	14.900	26.193

* bales of 170 kg

The average yield of seed cotton per hectare in India is around 1000 kg. This generates an income of 15.000 to 25.000 Rs per hectare for the farmer (= 300 to 500 $). The productivity of cotton lint of 300 kg/ha is relatively low as compared to other cotton growing countries, which on average yield 600 kg /ha (FAO / ICAC statistics). India has the worlds largest area under cotton, but ranks only at third position in production.

Apart from the valued cotton fibre, the cotton plant produces ligno-cellulosic biomass as a residue, which is either used as fuel by local farmers, or burnt at the field before the new crop emerges. Sometimes the cotton stalks are ploughed under for soil improvement. This practice is, however, not recommended because it is considered to be dangerous for transfer of pests from one season to the other. The average yield of cotton stalks is estimated to be 3 tons per ha. However, it may vary per cotton species or growing condition.

In the Southern zone (Dharwad), which is typically a rain fed cultivation, a relatively low biomass yields of 1-2 tons / ha dried cotton stalks can be expected. In this area cotton is grown on black and red soils, predominantly by small stakeholders (1 ha). In more southern wet tropical regions, sometimes two times a year cotton can be harvested.

Better yields are obtained in the Northern zone (Sirsa), where irrigation is applied and relatively high biomass yields of 3-4 tons / ha can be harvested. Here both medium and larger stakeholders (up to 60ha) grow cotton on sandy loamy soils. Common practice is to harvest two crops a year of cotton and wheat in rotation. In the Central zone (Nagpur) the situation of cotton farming practice lies in between those of North and South zones. Cultivation is dependent for water supplies on rains. However, here an average biomass yield of 2-3 tons / ha of cotton stalks can be obtained. In this area the farming takes place on black and loamy soils, by small and medium stakeholders

Apart from climatic and soil conditions the yield of cotton stalks also depends on the species of cotton. The common cotton species grown in India are *Gossypium hirsutum* (2.2 million ha / 26%), *G. herbaceum* / *G. arboreum* (2.2 million ha, 26%) and also many hybrids (4.1 million ha, 48%), such as Desi and Hirsutum. The hybrids have been reported to give the highest yield of stalk biomass, while *G. herbaceum* / *G. arboreum* give the lowest yields. Recently the Indian Government (GEAC) has approved the commercial growing of genetically transformed cotton (Bt hybrids) raising expectations for higher yields for seed cotton.

Assuming 3 tons average stalk yield per ha and 8.5 million ha under cotton cultivation, a total estimate for cotton stalk availability in India would come to as much as 25 million tons.

4.2 Utilisation of cotton stalks as domestic fuel

The major use of cotton stalks is currently as local fuel for the farmers. They are piled near the houses or in the fields. Part of the stalks are offered for free to the cotton pickers as additional income. The remaining cotton stalks burned in the field before the next cotton crop will be emerging. Because the insects and pests affecting the cotton crop could survive in these residues removal of the stalks from

the fields is recommended. It was observed that small farmers were less inclined to sell their stalks, because they would require to purchase alternative fuel. It was estimated when a farmer would have to change to gas for fuel it would cost at least Rs 200 per month.

Other farmers, generally owning more than one hectare of land for cotton cultivation, indicated they would be willing to sell 50% of their stalks at a minimum price of Rs 500 – 600 ($ 10-12) per ton, which would be including costs of labour and transport. The larger stakeholders would be very much interested to sell their residual cotton stalks for at this moment they are not receiving any price for it. A minor part is given to local brick factories at the costs of labour.

		fuel	waste
small farmers (≤ 1 ha)	100%		-
medium		50%	50%
big farmers (>15 ha)		10%	90%

If the utilisation of cotton stalks as domestic fuel is estimated at 25 – 30%, the remaining available biomass for board production could still amount as much as approximately 18 million tons.

So it can be concluded that presently cotton stalks are available at a reasonable price. However, once the farmers come to know that these stalks are being utilised for commercial or industrial purpose, they may escalate the price of cotton stalks which might adversely affect the cost benefit ratio of the industry.

4.3 Supply chain

For industrial production of board materials from cotton stalk residues it is a prerequisite that the supply chain of raw materials from farmer to the factory gate is well organised so the plant can operate the whole year at the maximum capacity. Cotton is a seasonal crop and after February, when the cotton picking is complete, the stalks can be harvested until May, when the new crop is sown.

The primary production of cotton stalks implies the harvest, that could be performed by two methods: cutting or up-rooting. Cutting just above ground level has the advantage that less sand will contaminate the stalks, but also reduces the weight of the harvested biomass. This method allows easy mechanisation and up-scaling. As a disadvantage the remaining stub could be the source of transfer of pests. Up-rooting is now commonly applied in most cotton growing areas in India, for which a special hand-operated device for cotton stalk up-rooting is available.

Currently the cotton stalks are piled in the field or near the farm house, unprotected from weathering and decay. Effects of moisture, infection with moulds or invasion of insects will deteriorate the quality of the stalks for board production. Moreover, the dispersed stocks of cotton stalk will require a constant concern for the user of collection of good quality raw material. Organisation of a local raw material collection centre, where the raw material can be stored dry during wet seasons would secure the supplies of cotton stalks to the factory.

The transport from farm to factory of the bulky cotton stalk (0.14 kg/m^3) will become uneconomical when the distances exceed 10 km. At maximum approximately one ton of stalks can be transported on a lorry, so compaction would be required. Therefore chipping right at the field or close to the site of primary cotton production has to be considered. In condensed (chipped) form at least 4 tons of stalks can be loaded on one lorry.

Depending on the board production capacity of the manufacturing plant the supplies of cotton stalks need to be adjusted. When the plant is located in the proximity of the cotton growing area farmers may directly bring their cotton stalks at the gate, where storage, chipping and cleaning takes place subsequently, before a board is pressed.

In the pre-processing steps part of the stalk biomass will be lost. A rough calculation by CIRCOT, which is conservative in its estimated losses, estimates an average overall yield of 1.2 ton dried chipped and cleaned stalks per hectare, including 25% consumption as domestic fuel. For the moisture content 20% weight reduction was accounted for. If cutting of the stalks on the field is performed 10% weight loss from the roots was estimated, while the losses in transportation, chipping and cleaning could even reduce the total raw material with 25%. There will be residues from cotton lint, leaves, boll rinds, bark and small twigs and adhering sand and dirt that have to be removed before board manufacturing. Summarizing: starting from an estimated average yield of 3 tons/ha of stalks, corresponding to 2.4 tons dried stalks, and after subtracting a total 35% loss in pre-processing would yield 1.5 to 1.6 tons per ha cleaned and dried cotton stalk chips. Reduction of this with the estimated 25-30% consumption of fuel comes to 1.05 – 1.2 tons dried chips on average available per ha of cotton.
Concluding: the availability of cotton stalk chips for board manufacturing in India could amount as much as 8.9 – 10.2 million tons per year.

4.4 Cotton Stalks collection and chipping centres

To guarantee the supplies to industries of a constant quality of cotton stalk raw material discussions on the establishment of intermediary chipping stations near the farms revealed that the need is felt by board manufacturing industries, especially in the case of high raw material demand and increased distances from farm to factory. The stock piles required by the factory could be prepared and stored at such station in the time between harvest and use by the factory. The advantage for the board manufacturer is a higher quality raw material (lower costs for cleaning, less waste) and a guaranteed and well-organised supply. Although it would increase the raw material costs. The residues produced from the chipping and cleaning should be considered for other added value use, such as briquetting for fuel or compost / growing substrate for mushrooms.

Other reasons to store the stalk material in chipped form is that it will be less prone to insect attack and the risk of fire hazard is considerably lower. With the prevention of spreading fire in mind the size of the stock piles and the distances between them have to be considered.

Additional to the income to farmers from selling the cotton stalks, development of an economic activity in pre-processing in such chipping stations would have beneficial socio-economic effects on rural cotton growing communities, providing labour and income.
Details on the operational cost and economy of scale need to be investigated for the different cotton growing zones.

The capacity of a chipping centre should be adjusted to the raw material demand of the industry and the distance to the farm, taking into account the transportation cost. The maximum distance from farm to chipping centre is estimated that it should not exceed 7.5-10 km, which corresponds to an area of 17.500 – 30.000 ha. Sufficient supplies for chipping of 5000 tons of cotton stalks would be possible from such area in all cotton growing zones. For a minimum sized board production plant of 30 tons / day capacity (requiring 9000 tons a year) two chipping stations would be sufficient.

4.5 Raw material demands of board manufacturing plants

The critical point in the discussions around supply and demand, is the scale of economic production of boards. Previous consultants from Europe have projected the West European scales of cost-effective operation in paper industries on the particle board industries of India. A commercial particle board plant in Europe would on average produce 1500 tons / day. Therefore, a 400 tons / day production capacity was considered the minimum economically viable production scale for the Indian situation. However, there are some comments to be added on these assumptions. The mentioned particle board plants in Europe are processing wood chips in the proximity of production forestry areas and have been designed to operate fully automated to minimise the labour costs. The required investments for such (imported) production plants will exceed the financial resources of investors for cotton stalk based boards. In India a fully automated production line is considered of less relevance, because the availability of cheap labour and the need for creation of jobs, especially in the rural areas. Moreover, in India there are currently no board production plants operational with capacities above 100 tons / day. The investment cost for a 30 ton/day capacity plant produced in India, would be 6 times lower compared to an imported production line from Europe.

The suggestion by the consultants to consider the demand on a board production plant for global competitiveness is valid for wood based production and export markets, but seems less relevant for the Indian situation and the objectives for added value for agro-residues from cotton growing and rural development.

Considering a board production plant with a minimum production capacity of 30 tons board / day or (assuming 300 operational days per year) 9000 tons / year, will require a cotton stalk input supplies from estimated area of approximately 9.000 ha under cotton. This corresponds to an area radius of 10 km. In such case

separated collection and chipping centres may not be necessary and farmers may supply directly to the factory.

In case of the suggested production capacity of 400 tons board / day or 120.000 tons / year the cotton stalk input requirement corresponds to the supplies from estimated area of approximately 120.000 ha under cotton or an area radius of 35 km. In such case the organisation of the supplies and several collection and chipping centres will be highly relevant.
One of the first demands on an alternative raw material for a manufacturer will be that it should be available at a competing price. Currently the price paid for sugar cane bagasse by the particle board industries is 1000 Rs per ton ($ 20). This is uncleaned and a substantial part of the material (dust and nodes) will be rejected and removed in the cleaning. This can then be used as fuel in a boiler for drying and processing heat.

Since the farmers now receive nothing for the cotton stalks they may sell at any price. Farmers will ask minimum price of Rs 500 for costs of labour and transport to chipping centre / factory (within 10 km range), so there seems to be a margin for cotton stalks as competitive raw material for board production. Local board manufacturing industries, now operating on sugar cane bagasse have indicated to be interested in this raw material.

4.6 Cotton stalks quality

Cotton stalks are known to have similar composition to many common wood species. The quality of cotton stalks for board production is depending on what type of board is produced. For particle board manufacturing the particle size distribution is important and the composition of bark and woody material. For particle board production it is known that the particle size distribution affects board density and surface properties. Too much fines will absorb too much glue. Also the content of bast fibre has a negative effect on the amount of glue required. Relatively, the glue is the highest expense in the board manufacturing process, so removal of the bast and fines will make the process more economic.

In the case of binderless fibre board production the bast fibre improves strength. Therefore the pre-cleaning steps of the cotton stalk material are less demanding. However, the cotton stalk processing requires refining or thermomechanical pulping (TMP) , which processing conditions has to be optimised for combined bast and wood refining.

The cotton stalks may contain residues from pesticides since in India cotton cultivation requires use of a relatively high quantity of chemicals for crop protection. Residues of these chemicals may be present on the cotton stalks, in the finished products or in the effluent. These chemicals may be harmful to the eco-system as well as to the end user of the finished products. Regarding the stability of the chemicals used it is unlikely that residues will remain in the end products after the hot pressing steps during board manufacturing. However, careful assessment of the safety of handling in the various steps in the process – from harvest and chipping to the end-use – is recommended.

4.7 Particle board market

A conservative estimation of 10 million tons available cotton stalk raw material in India for board production, which would correspond to a feed stock for as much as 350 plants of 100 tons / day production capacity. The current production of particle boards in India does not exceed 2.4 million m^3 (= 0.06 % of 40 million m^3 world production) or (at a density of 0.75 g/cm^3) 1.8 million tons per year. The available cotton stalks in India could completely substitute for the raw material supplies of the largely wood based particle board industries if the quality and price would be equal. If the board products can be produced at competitive prices and find acceptance in the market, a huge potential for wood free boards may be opened in India and elsewhere.

5 Conclusions

Additional income to farmers

On average, about 2.5 to 3.0 tons of cotton stalks are generated for every hectare of cotton cultivation. These stalks presently do not find commercial application and are disposed off by burning. If these stalks are used for production of value added products like particle boards and binderless boards, they may fetch an income of about US$ 20 per hectare to the cotton growers which will be approximately a 5% additional income above their normal profit based upon an income of 15.000 to 25.000 Rs per hectare to the farmer for seed cotton (= 300 to 500 $). Farmers, and especially the larger stakeholders, are ready to supply. Small farmers (<1 ha) are less inclined to sell their stalks because they utilise it as fuel source.

A new raw material for board manufacturing industry

Presently the board manufacturing industry is dependent on forestry based raw materials. Acute scarcity of these raw materials due to environmental considerations and Indian Government policies on deforestation have threatened closure of these units. Use of cotton stalk as a renewable raw material for manufacture of boards can provide these industries with a sustainable alternative.

Avenues for setting up rural industry

Development of cost-effective technologies for the preparation of value added products from cotton stalks and demonstration to interested entrepreneurs opens up avenues for establishment of rural industries in cotton growing areas in India, including pre-processing and collection centres.

Employment opportunities for rural youth

Unemployment is a serious problem encountered in many rural areas in both developing and underdeveloped countries of the world due to lack of infrastructure facilities and industries. To stop the migration of large numbers of rural youth to urban areas - in search of employment thereby causing overcrowding of cities and creating additional problems – novel opportunities need to be offered locally. Setting up industries based on cotton by-produce may help in generation of employment opportunities in rural areas which will contribute to reduce migration of rural youths to urban areas.

Conservation of forest resources

Forest timber is being used for furniture, in construction industry and as raw material for the manufacture of board materials, etc. The demand for wood is high and impossible to meet from existing forests, which are depleting very fast. Under such circumstances, promotion of cotton stalks, as a renewable and naturally available substitute lignocellulosic material, will have a significant impact in arresting the environmental degradation and conserving forest resources.

Industrial interest in using alternative resources for board manufacturing

Keen interest of board manufacturers could be observed for a cheap alternative raw material, if supplies of sufficient quantities of good quality cotton stalk chips can be ascertained. The quality of cotton stalks, as raw material for board making is considered sufficient after pre-processing and cleaning. The best practice for pre-processing and supplies need investigation.

Availability

Industrial exploitation of cotton stalks will mainly depend upon availability of cotton stalks in bulk quantities to the industry throughout the year. Since cotton crop is seasonal, an economically viable methodology has to be developed for collection, transportation and storage for future consumption by the industry. Safe storage in adequate quantity should enable maintenance of quality of cotton stalk. This means protecting it form weather, insects, pests, etc. that can cause deterioration of stalks.

It is estimated that about 3 tons of cotton stalks are obtained from one hectare of land. The moisture content of the dry cotton stalk is generally around 20%. The stalks at this stage contain about 15% trash and impurities. About 10% of stalks in the form of roots remain in the field which can not be collected. About 25% of the stalks are lost in chipping, compacting and transportation. Taking into account all these losses, an estimated 1 ton yield of chipped and dried cotton stalks can be expected from one hectare of land. India has about 8.5 million hectares of land under cotton cultivation, hence the availability of cotton stalks for industrial application will be at least 8.5 million tons on dry weight basis.

Supply chain

In order to organise the supply chain for cotton stalks co-operative societies or collection centres could be set up in the cotton growing areas for collection, storage and pre-processing of cotton stalk. Reduction of the bulk volume of the stalks by chipping will be required if distances for transportation to the factory gate become longer. An additional rural activity would emerge from this.

Cotton stalks are branched and consequently stocking and feeding to a chipper is complicated. Bulk density of cotton stalk is very low, hence problems are encountered in handling and transportation. This can result in increase in cost of transportation thereby affecting the economics of production of finished goods.

Hence, a systematic study will be undertaken for economic collection, transportation and storage so that cotton stalks are made available to industry in a sustained manner at competitive price.
Various models of supplies of cotton stalks should be examined varying from chipping at the farm and direct delivery to the factory to organised collection, transport and storage for conversion at pre-processing plants for chipping and cleaning.

Research on up-scaling of pre-cleaning and raw material demands for optimal board production will be required for successful implementation in board manufacturing industries.

Economy of scale for board production in India

For the whole exercise it is essential that the economy of scale is addressed, which will identify the suitable production scale for the Indian situation, with respect to logistics and investments. Currently operating particle board plants in India generally do not exceed 60 tons/day capacity. Therefore it is essential that local machine manufacturers are involved, rather than investing in expensive fully automated imported equipment, which will enhance the production efficiency, but will not provide much perspective for job creation.

Demonstration of economic feasibility of the whole supply and production chain for cotton stalk based board manufacturing requires data collection on logistics and techno-economic efficiency of board production processes.

Opportunities to enter into the existing market of particle boards by production of blends of cotton stalks with other lignocellulosic particles (bagasse, wood chips, rice straw) is recommended.

It is recommended that close and active involvement of the private sector is obtained, both the existing board manufacturers and equipment suppliers, but also potential investors for setting up new production facilities for board manufacturing in rural cotton growing areas.

6 Persons contacted

Many persons during the two weeks in India have been consulted on the above described topics of cotton stalk value addition. At local level discussion were held with farmers and village representatives, at the various institutes visited much valuable information was obtained from scientists and technicians. Technical details and practical data were obtained from directors and plant managers of board manufacturing companies. Much I am indebted of course the CIRCOT staff members who have guided me along the various aspects of Indian cotton productivity. The most prominent persons are listed here below:

Scientists

Dr S. Sreenivasan	Director	CIRCOT, Mumbai
Dr R.H. Balasubramanya	Principal Scientist	CIRCOT, Mumbai
Dr A.J. Shaikh	Principal Scientist	CIRCOT, Mumbai
Mr R.M. Gurjar	Principal Scientist	CIRCOT, Mumbai
Dr K.M. Paralikar	Principal Scientist	CIRCOT, Mumbai
Dr P.M. Varadarajan	Principal Scientist	CIRCOT, Mumbai
Dr S.A. Patil	Vice-Chancellor,	Univ. Agric. Sci., Dharwad
Dr S.B. Patil	Scientist	Univ. Agric. Sci, Dharwad
Dr J.H. Kulkarni	Director of Instruction	Univ Agric. Sci, Dharwad
Mr V.B. Nadkarni	technologist	Dharwad
Dr D. Monga	Head	Regional Station CIRCOT, Sirsa
Dr C.D. Mayee	Director	CICR, Nagpur

Board manufacturers

Mr V.S. Raju	Ecoboard Industries Ltd, Pune
Mr. S.S. Kalive	Ecoboard Industries Ltd, Pune
Mr Nitin Vaze	Sleek Boards (Pvt) LtD, Pune
Mr V. Bhatkhande	Sleek Boards (Pvt) LtD, Pune
Mr Kolambe	M/s Jollyboards Ltd, Mumbai
Mr A Khati	Aurobindo Laminations Ltd, Nagpur
Mr R.N. Konar	Aurobindo Laminations Ltd, Nagpur

Engineering companies

Mr M.T. Geevarghese	Grace Enterprises, Nagpur
Mr K.G. Bhat	Precision Tooling Engn, Nagpur
Mr M.K. Sharma	Bajaj Steel Industries Ltd., Nagpur
Mr R.K. Bhutoria	Bajaj Platics Ltd, Nagpur
A.J. Phadke	IndoPacific Engn (Pvt) Ltd., Pune

Officials and consultants

Mr V. Nath	Chairman Cotton Corp. India, Mumbai
Dr R.P. Kachru	ICAR, Mumbai
Mrs C. Shah	Deloitte, Haskins & Sells, Mumbai
Dr V.R. Gadwal	Mahyco Ltd, Mumbai
Dr T.P. Rajendran	CIRCOT, Reg. Station, Coimbatore
Mr V.Kannan	Dept Dir. Agriculture, Govt Tamil Nadu, Chennai
M. S.P. Anup Kumar	M/s Marketing Serv Pvt. Ltd, Mumbia
Mr A Dey	NIRJAFT, Calcutta