Priority Cotton By-products Activities for Development

National Capacity Building Workshop (UNCTAD)

Lusaka, Zambia, December 6-8, 2017






Dr. C. Sundaramoorthy

Senior Scientist (Agricultural Economics)

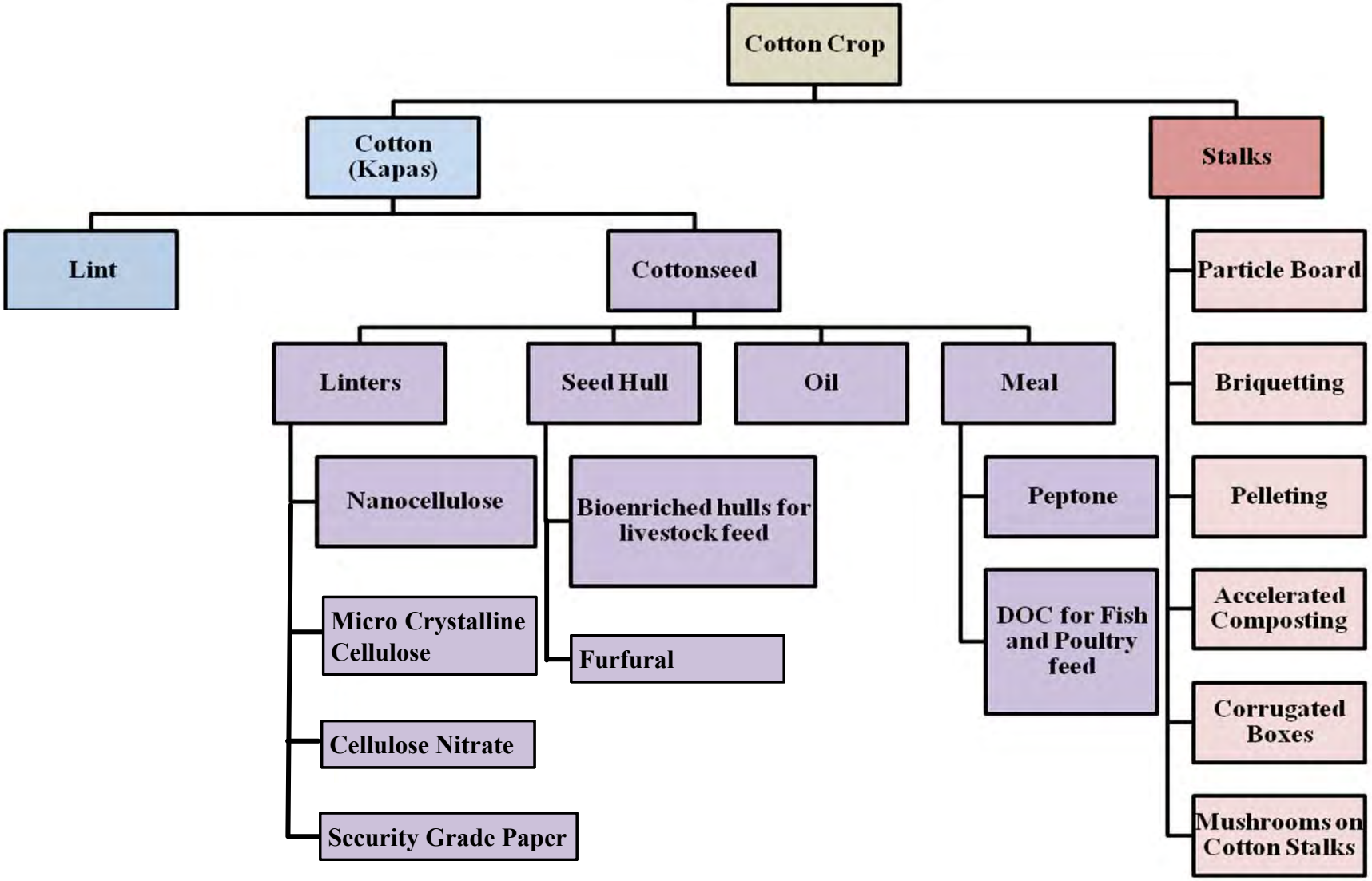
ICAR-Central Institute for Research on Cotton Technology (CIRCOT)

Ministry of Agriculture and Farmers Welfare, Govt. of India

Cotton Sector in India (2016-17)

- **Area Under Cotton Cultivation** : **10.5 million hectares**
- **Cotton Production** : **5.88 million tonnes**
- **Cottonseed production** : **11.5 million tonnes**
- **Cotton Stalk Production** : **26 million tonnes**
- **Cotton Farmers** : **5 million**

Value Addition to Cottonseed and Stalks

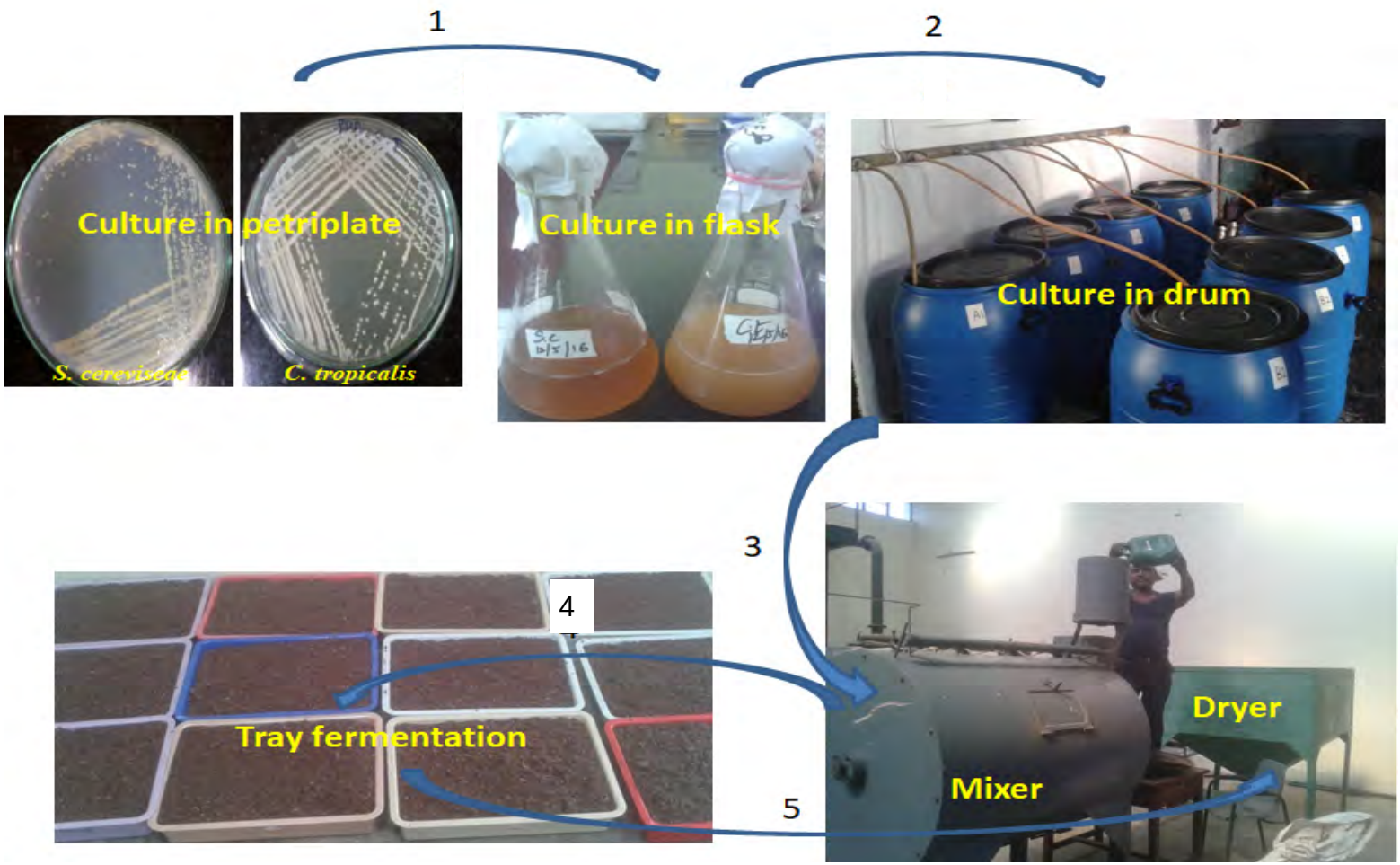


Industrial Applications of Cottonseed Meal

Cottonseed cake: India's Experiences

- Availability : 5.75 million tonnes annually
- Oiled Cake: 5.4 m tonnes and De-oiled cake: 0.35 m tonnes
- Uses: Mostly used for ruminant feeds
- Total gossypol content: 0.6 - 1.15% (0.05 – 0.7% free gossypol)
- Gossypol: Limitation to non-ruminants like fish and Poultry
- Large scale production of degossypolised meal under trials
- Small scale production of degossypolised meal for poultry and fish feeding, etc. using CIRCOT technology

CIRCOT : Degossypolization Technology



Degossypolized Cottonseed Cake

- CIRCOT microbial process
  - Reduction of free gossypol content (80%),
  - Reduce bound gossypol (60 %),
  - Reduce crude fibre (30%)
  - Improvement of protein content (40%)
  - Improvement in lysine content (25%)
- Gossypol level meets standard: UN's Protein Advisory Group (UPA)
- Enable Cottonseed meal for Poultry and Fish feed
- Human Protein Supplement

Pilot Scale Production: Degossypolised cake

A	**Capital Investment (1 TPD Capacity)**	**INR (Mn.)**	**USD**
	Land and Building (Land Area: 2000 sq. m; Building for Machinery: 50 Sq. M ; Material storage area:500 Sq. M ; Office Building: 40 Sq. M)	0.50	7,962
	Plant and Equipment	0.90	13,846
	Auxiliary and Service Equipment (Electricals and handling tools)	0.10	1,538
	Total investment	**1.50**	**23,077**
B	**Operational Expenses**		
	Raw Material Cost for 6 months(1 TPD for 150 days @ Rs. 20,000 per tonne)	2.40	73,846
	Operational cost including repair and Maintenance and other charges (Rs. 3000/tonee) for 1 year	0.72	11,077
C	**Gross Annual Income (Rs. 25000/tonne)**	**6.0**	**93,308**
	Net annual income (Rs. 2000/tonne)	**0.48**	**7,385**
D	Payback period: **38 months** Return on investment : **26.3%**		

Cottonseed Hulls

- Hulls contain about 35%-47% of alpha cellulose, 19%-27% pentosans, 15%-20% lignin, 5% ash, protein, fats, etc.

Uses:

- For extraction of Furfural, an industrially important chemical
- Good roughage and commonly used in feed lot and dairy rations

Enhanced utilization of Hulls through Bio-enrichment

- Digestibility and crude protein content of Hulls can be enhanced by fermentation
- With increased digestibility and enhanced level of crude protein it can be used as cattle feed

Industrial Applications of Linters

Linters from Cottonseed: India's Experiences

Short fuzzy fibres from cottonseed

Uses

- Cellulose Nitrate (explosives)

- Cellulose acetate (film, membranes etc.)

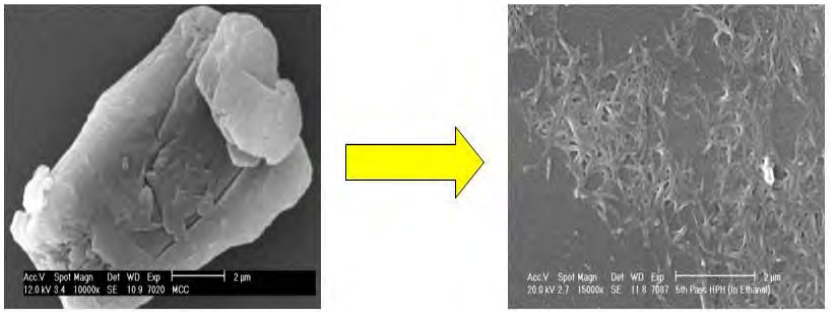
- High grade paper (currency, security)
- Medical grade cotton (Absorbent)

- Micro Crystalline cellulose (Filler in Tablets)
- Food Casings, Felts

Nanocellulose from Cotton Linters

Nanocellulose (size < 100nm)

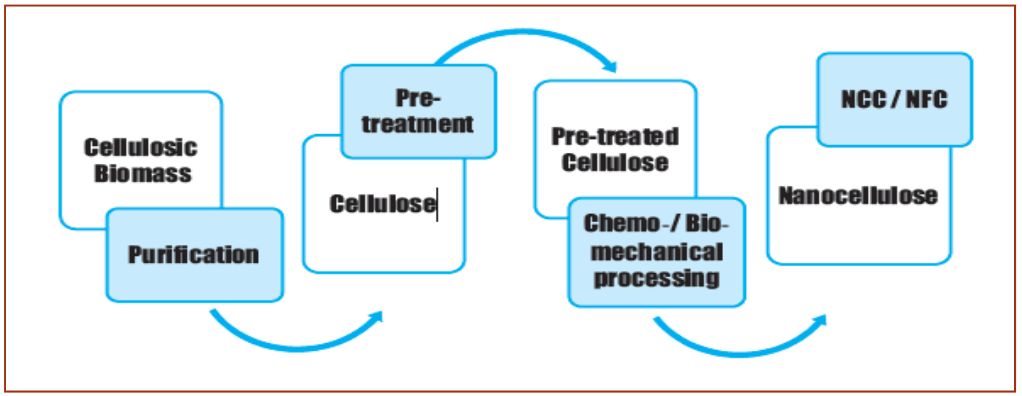
- ✓ High mechanical strength (1 to 10GPa)
- ✓ High young modulus (100-130GPa)
- ✓ High surface area (50-200 m^2/g)
- ✓ Bio degradable
- ✓ Novel optical properties



MCC from Cotton Fibers | Nanofibrils

ICAR-CIRCOT pilot plant with capacity of 10kg/day

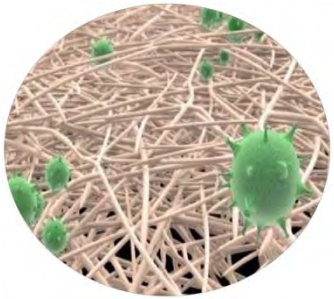
5th Pilot Plant in the World (1st Plant in Sweden – 2011)



ICAR-CIRCOT Process

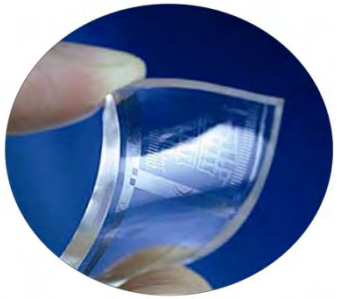
Applications of Nanocellulose

Virus filtration



Emulsion/ dispersion stabilizer

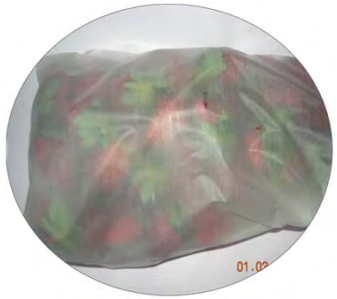
Liquid Crystal Display



Non-caloric Food thickeners

Targeted drug delivery

Fillers in Cement



Fillers in Film

Paper Coating & Furnish Additives

Industrial Applications of short staple/comber noil cotton

Short staple/comber noil cotton: India's Experiences

- **Availability : 0.25 million tonne annually**
- **Properties: staple length < 20 mm, MIC: 3-5; strength: 25g/tex Trash: 0.1-0.25%**
- **Commercial Uses: Surgical Cotton, medicated cotton, Cotton Ball, Ear buds, wadings, security paper, currency notes, blend for coarse yarn and OE spinning for denim production**
- **Under Trials: Technical Textiles, etc.**

Standard of Absorbent cotton

Raw Material	Virgin Cotton/Comber noil
Sinking Time/absorbency	< 10 Sec
Water Holding Capacity	Not less than 24 times of It's weight in water
Ether Soluble Substances	Max 0.50 %
Water Soluble Substances/Per 5g	Not more than 0.50%
Alcohol Extract	Colorless
Sulphate Ash	Max 0.40%
Surface Active Substances	Max 2mm
Mercury	None when examined under ultraviolet light
Odor	Odorless
Foreign Matter	Absent
Extractable Coloring Matters	Negative
Moisture (%)	8

Absorbent Cotton Preparation Process

i. Bale opening- manual or machine

ii. Pre-cleaning & opening- cleaner

iii. Kier/HTHP bleaching (100 ^{0}C Temp and 4 bar pressure using wetting agent, NaOH and H_2O_2

iv. Neutralization and Hydro extraction

v. Wet opening

vi. Drying

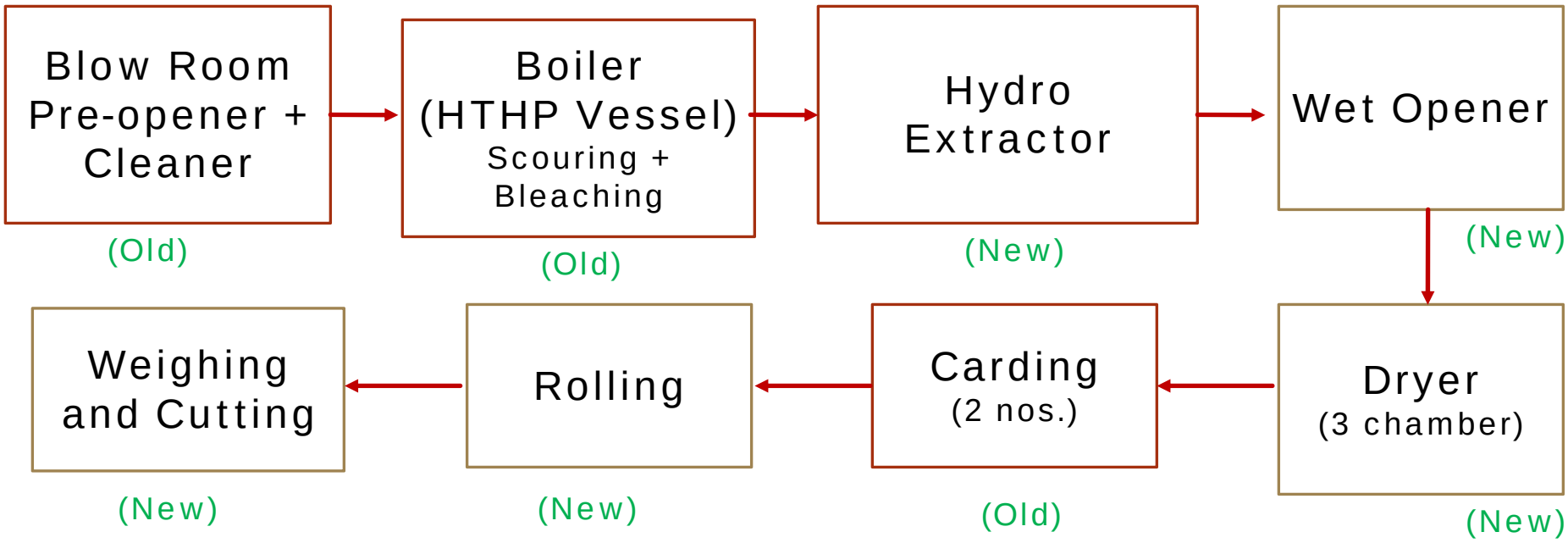
vii. Carding

viii. Cutting, weighing

ix. Packaging

Flow Chart for Absorbent Cotton Plant

- Capacity: 1.5 TPD for 3 shifts (Semi automatic can be converted to fully automatic)



Commercial utilization: Absorbent Cotton

A	Capital Investment (1.5 TPD Capacity)	INR (Mn.)	USD
	Land and Building (Land Area: 1000 sq. m; Building for Machinery: 600 Sq. M ; Material storage area:200 Sq. M ; Office Building: 300 Sq. M)	**0.50**	**7,692**
	Plant and Equipment	**4.00**	**61,538**
	Auxiliary and Service Equipment (Electricals and handling tools)	**0.50**	**7,692**
	Total investment	**5.0**	**76,923**
B	**Operational Expenses**		
	Raw Material Cost for 1 year (1.5 TPD for 300 days @ Rs. 90,000 per tonne)	**40.05**	**616,153**
	Operational cost including repair and Maintenance and other charges (Rs. 40,000/tonee) for 1 year	**18.0**	**276,923**
C	**Gross Annual Income (Rs. 1,900,00/tonne)**	**85.5**	**1,315,384**
	Net annual income (Rs. 50,000/tonne)	**2.25**	**34,615**
D	Payback period: **27 months**	Return on investment : **37%**	

Cotton Stalks: India's Experiences

- **Availability : 26 million tonnes annually**
- **Utilization: 5-6 % commercially utilized, 15-20 % Domestic fuel, 10-12% ploughed in field, rest is burnt.**
- **Properties: about 60% holocellulose, 27% lignin and 6% ash, Gross calorific value: 4000 kcal/kg**
- **Commercial Uses: Briquettes, Pellets, Compost, Power generation**
- **Under Trials: Particle Board, Pulp and Paper, Hard Boards, etc.**



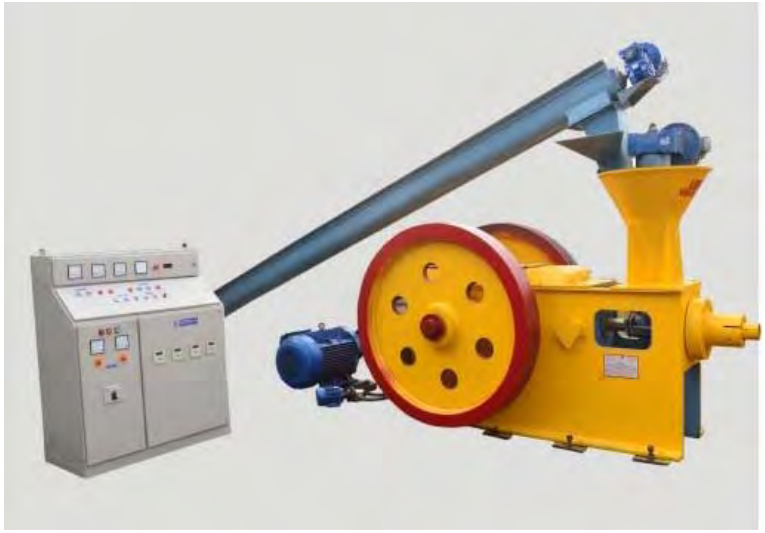




Commercial Utilization of Cotton Stalks in India

Briquetting Plants

- Installed plants: about 110
- Capacity/plant: 20 TPD
- Size of briquettes: 90 mm diameter
- Uses: As substitute for coal for firing boilers in industries, brick kilns, etc.



- Raw materials: Cotton Stalk (150,000 T for 4 months:); Soybean; saw dust, wood chips, bagasse, etc.,
- Benefits: Cheap-80% of Coal Price; Renewable Source,

  farmers' income-Rs. 3000/ha for supply of chipped biomass

Commercial Utilization of Cotton Stalks in India (Contd.)

Pelleting Plant

- Installed Pelleting plants : **50**
- Capacity/plant: **3 TPD & 60-80 TPD**
- Size of pellets: **6, 8 and 10 mm diameter**
- Uses: **Boilers and Cooking in Restaurants**

- Raw materials: **Cotton Stalk (200,000 T for 4 months:); Soybean; saw dust, wood chips, bagasse, etc.**
- Benefits: **Cheap- half the commercial LPG prices; farmers' income-Rs. 3000/- per ha for supply of chipped biomass**

Commercial Utilization of Cotton Stalks in India (Contd.)

Power Generation

- Installed power plants: 225
- Installed Capacity: 4831 MW
  (Ministry of New and Renewable Energy, 2016)
- Raw material Required: 48 TPD for 1 MW capacity

- Cotton Stalk, Soybean, Bagasse, Saw dust, etc.
- Benefits:
  - Renewable source for power generation
  - Power plants accept cotton stalks with high moisture content:50 - 60 %
  - farmer' income-Rs. 3000/- per ha for supply of chipped biomass

Commercial Utilization of Cotton Stalks in India (Contd.)

Particle Boards

- One ton Stalk used for 600 Kg Boards
- Plants accept Cotton Stalks as Substitute for Bagasse
- Particle Boards from Cotton Stalk conform with IS standard 3087-1985
- Uses: furniture making, partitioning, panelling, false ceiling, etc.

On-farm Utilization of Cotton Stalks

Compost

- **CIRCOT accelerated process for compost preparation.**
- **Compost is enriched with nutrients, plant growth micro organisms**
- **Stable for the period up to one year.**

Mushroom Production

- **Oyster Mushroom (edible) can be grown from cotton stalks**
- **Mushroom yields up to 500 g per kg of cotton stalks**

Parameter	Compost from cotton stalks	Farm Yard Manure
NPK content (%)	1.43 : 0.78 : 0.82	0.5 : 0.2 : 0.5
Duration (Days)	60	120

Industrial Applications of Cotton Stalks

BRIQUETTING

Chipped Cotton Stalks/Soya/Bagasse → Manual or Tractor Feeding → Screw Conveying → Briquetting by Extrusion

PELLETTING

Chipped & Milled Cotton Stalks/Soya/Bagasse → Manual Feeding → Pelleting by Extrusion

POWER GENERATION

Chipped Cotton Stalks/Soya/Bagasse → Tractor feeding → Steam generation → Power generation

Connected Loads & Manpower

Briquetting plant (mechanical)

- ❑ **Connected load:** 90 HP
- ❑ **Manpower requirement:** 6/shift

Hydraulic Press: capacity: 0.5 t/h , 20HP

Pelleting plant

- ❑ **Connected load:** 25 HP
- ❑ **Manpower requirement:** 3/shift

Power Generation

- ❑ **Manpower requirement:** 10/shift

Logistics for Supply of Cotton Stalks

- Uprooting of cotton stalks: 7-10 labour/ha
- Collection after 1 week sun drying: 4 labour
- Chipping: Tractor driven chipper, capacity 2 TPH, 11 labour, 2 tractor cum trolleys
- Transportation: within 50 km
- Total logistics Price: Rs. 1500 per tonne at factory gate ($ 23 per tonne)

Commercial utilization: Briquetting Plant

		INR in million	USD
A	**Capital Investment (20 TPD Capacity)**		
	Land and Building (Land Area: 2 acre; Building for Machinery: 150 Sq. M ; Material storage area:1000 Sq. M ; Office Building: 50 Sq. M)	**1.50**	**23,077**
	Plant and Equipment	**2.50**	**38,462**
	Auxiliary and Service Equipment (Chipper: 3 & Handling Tools)	**0.50**	**7,692**
	Total investment	**4.50**	**69,231**
B	**Operational Expenses**		
	Raw Material Cost for 1 year (20 TPD for 300 days @ Rs. 2800 per tonne)	**16.80**	**258,462**
	Operational cost including repair and Maintenance and other charges (Rs. 600/tonne) for 1 year	**3.60**	**55,385**
C	Gross Annual Income (Rs. 4000/tonne)	**24.00**	**369,231**
	Net annual income (Rs. 400/tonne)	**2.40**	**36,923**

D Payback period: **23 months** Return on investment : **43.5%**

Commercial utilization: Pelletting Plant

		INR in million	USD
A	**Capital Investment (3TPD Capacity)**		
	Land & Building: (Land Area: o.5 acre; Building for Machinery: 100 Sq. M ; Material storage area:500 Sq. M ; Office Building: 50 Sq. M)	**0.50**	**7,692**
	Plant and Equipment	**1.00**	**15,385**
	Auxiliary and Service Equipment (Chipper: 1 & Handling Tools)	**0.20**	**3,077**
	Total investment	**1.70**	**26,154**
B	**Operational Expenses**		
	Raw Material for 1 year (3 TPD for 300 days @ Rs. 2800 per tonne)	**2.52**	**38,770**
	Operational cost including repair and Maintenance and other charges (Rs. 2950/tonne) for 1 year	**2.66**	**40,923**
C	**Gross Annual Income (Rs. 7500/tonne)**	**6.75**	**103,846**
	Net annual income (Rs. 1000/tonne)	**0.54**	**8,308**

D Payback period: **33 months** Return on investment : **30.3%**

Commercial utilization: Power Generation

		INR in million	USD in million
A	**Capital Investment (30 MW Capacity)**		
	Land and Building (Land Area: 5 acre; Building for Machinery: 50 Sq. M ; Material storage area:5000 Sq. M ; Office Building: 50 Sq. M)	**100.0**	**1.53**
	Plant and Equipment	**800.0**	**12.37**
	Auxiliary and Service Equipment (Crushers, Gridding, Chimney, etc.)	**100.0**	**1.53**
	Total investment	**1,000**	**15.43**
B	**Operational Expenses**		
	Raw Material Cost for 1 year (1500 TPD for 360 days @ Rs. 2800 per tonne)	**1,510**	**23.23**
	Operational cost including repair and Maintenance and other charges (Rs. 30000/MWh) for 1 year	**7,776**	**119.63**
C	**Gross Annual Income (Rs. 57000/MWh)**	**14,775**	**227.29**
	Net annual income (Rs. 1000/MWh)	**250**	**3.84**

D Payback period: **48 months** Return on investment : **25%**

On-farm Applications of Cotton Stalks

Composting from Cotton Stalks

- **Bio-enriched compost with nutrients, plant growth micro organisms prepared using ICAR-CIRCOT Accelerated process of composting**

Parameter	Cotton stalk Composts	FYM
NPK content (%)	1.43 : 0.78 : 0.82	0.5 : 0.2 : 0.5
Duration (Days)	60	120

- **Yield: 800 kg/tonne chipped stalks**
- **Production cost: Rs. 3000/tonne**
- **Selling Price: Rs. 3500/tonne**

CIRCOT Technology for Bio-enriched Composts from Cotton Stalks

1 Tonne Chipped cotton stalks

↓

0.2% NaOH

↓

10% cattle dung

↓

1.2% Urea and 2% Di-ammonium Phosphate

↓

1% microbial consortia

↓

50% Water

↓

Through mixing and heaping

↓

Cover with polyethylene sheets

↓

Mixing of heaps every week for aeration

↓

Bio-enriched Compost (After 60 days)

Mushroom from Cotton stalks

- Oyster Mushroom (edible) can be grown from cotton stalks
- Mushroom yields up to **500 g per kg of cotton stalks**

Mushrooms grown on cotton stalks

Cotton Sector in Zambia 2017

- **Area Under Cotton Cultivation : 130,000 hectares**
- **Cotton Lint Production : 46,000 tonnes**
- **Cottonseed production : 65,000 tonnes**
- **Linters : 3,900 tonnes**
- **Hulls : 14,300 tonnes**
- **Cottonseed meal : 35,750 tonnes**
- **Cotton Stalk Chips : 325,000 tonnes**

Source: estimated based on USDA data

Bottom line

- **Cottonseed meal is well established product for animal feeding, however, it can be explored as poultry and fish feed.**
- **Utilization of Cottonseed oil is well established and is recognized as safe edible oil across the World**
- **Bioenrichment of Hull will enable it as good feed supplement**
- **Explore the option of Absorbent cotton Production**

Bottom line

- Cotton stalks can be effectively used as Renewable source of energy : Briquettes, Pellets and Power generations

- Promote on-farm composting of cotton stalks: Reduction in input cost; Soil health improvement; increased productivity and Production of cotton.

- From cotton stalks, preparation of Kraft paper (corrugated boxes) and Particle Boards is not a feasible proposition

Announcement

International Training Programme

- ICAR-CIRCOT offers International Training cum Exposure programme on "Post-Harvest Processing of Cotton and value addition to crop residues" to African Nationals

- Fourth coming training programme in this series is scheduled during 19.02.2018 to 03.03.2018, Nagpur

Thank You

ICAR-Central Institute for Research on Cotton Technology
Adenwala Road, Matunga, Mumbai – 400019
(www.circot.res.in)

Tel. (+91) 22 24127273/76, 24184274/75
E-mail: sundaramoorthy.c@icar.gov.in