UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

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UNCTAD Project 1617K's

STUDY VISIT ON COTTON BY-PRODUCTS in Nagpur, India

14-18 January 2019

Hosted by:

CIRCOT
ICAR - Central Institute for Research on Cotton Technology

Report of the Study Visit

in partnership with
United Nations Economic Commission for Africa (UNECA)
and Common Market for Eastern and Southern Africa (COMESA)

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UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

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UNCTAD Project 1617K
Promoting Cotton By-Products in Eastern and Southern Africa

Study Visit on Cotton By-Products in India

Hosted by
Central Institute for Research on Cotton Technology (ICAR-CIRCOT)
Ginning Training Centre, Nagpur, India
14 - 18 January 2019

Report of the Study Visit

Report prepared by: Dr. A. J. Shaikh, former Director, ICAR-CIRCOT

Geneva, February 2019

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http://unctad.org/en/Pages/SUC/Commodities/SUC-Project-1617K.aspx

The work was supervised by Mr. Kris Terauds, Economic Affairs Officer, under the direction of Ms. Yanchun Zhang, Chief, Commodity Policy Implementation and Outreach Section (CPIOS), in UNCTAD's Commodities Branch.

While due care was taken in compiling and reviewing this report, any errors and omissions remain the author's responsibility.

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Introduction

Cotton remains an important crop in Eastern and Southern Africa (ESA), generating export revenues, value added and cash income for rural populations. Although cotton is grown primarily for its lint – the raw material in cotton textiles – other parts of the plant also have commercial value. For example, mature industries exist in many cotton-producing countries in Africa to process cottonseed into edible oil and livestock feed. Nevertheless, technologies to add value to other parts of the cotton plant or residues – such as cotton stalks, linters or ginning waste – are largely absent in African countries, amounting to unrealised economic opportunities.

Cotton by-products industries are underdeveloped in ESA owing to several impediments, including inadequate policies to support the development of cotton by-products industries; insufficient data to assess the viability of investments in cotton by-products; and a lack information about value added technologies available in other countries.

The United Nations Conference on Trade and Development (UNCTAD) designed the technical cooperation project "Promoting cotton by-products in ESA"[1] to address some of these gaps and assist ESA countries in capitalising on opportunities in cotton by-products. Together with its partners, the Common Market for Eastern and Southern Africa (COMESA) and the United Nations Economic Commission for Africa (UNECA), UNCTAD is implementing the project from 2016-19 in Uganda, the United Republic of Tanzania, Zambia and Zimbabwe.

As part of the project's programme of activities, UNCTAD organized a study visit in January 2019 to allow participants from the four countries to see examples of these cotton by-product technologies in operation, including learning from entrepreneurs how to run their businesses and market their products.

UNCTAD selected the Central Institute for Research on Cotton Technology (CIRCOT) as the most relevant institution to host the study visit. This follows from CIRCOT's valuable contributions to the project's four national workshops. In addition, similarities between the cotton production model employed in India and the four project countries – for example, in both cases, cotton is mainly hand-picked on small farms – mean that the value-added technologies developed at CIRCOT and commercialised in India are often well-suited to the African context, improving the potential for cotton farmers and entrepreneurs in ESA to benefit from their adoption.

Value addition technologies

The study visit focussed on three cotton by-products judged to have the greatest commercial potential in ESA,[2] namely:

- Briquetting and pelleting of cotton stalks;
- Processing of short-staple and waste cotton into absorbent cotton wool; and
- Removal of gossypol from cottonseed meal.

[1] For more information, please visit the project site: https://unctad.org/en/Pages/SUC/Commodities/SUC-Project-1617K.aspx.

[2] Earlier project activities included surveys in each of the countries, which informed national capacity-building workshops, where stakeholders agreed on which cotton by-products to develop as part of a National Action Plan. The three selected cotton by-product technologies reflect those that recur in the project countries' National Action Plans.

Objectives

According to the project's logical framework, the study visit (A 1.4) was intended to contribute to the following expected achievement:

Expected project achievement:

EA1 Improved capacity of cotton value chain stakeholders to assess the potential value, market situation and prospects for cotton by-products.

Indicators:

IA 1.1 Four target countries have collected and analysed statistics on the cotton by-products value chain, including the availability of raw material, processing and market conditions of these by-products (i.e., cottonseed and/or stalk).

IA 1.2 National action plans aiming to increase the value added of cotton by-products have been developed and adopted by cotton value chain stakeholders in at least three of the four target countries.

To this end, UNCTAD designed the study visit to:

- Demonstrate to participants the operation of the cotton by-product processing technologies developed by CIRCOT;
- Provide detailed examples of commercial enterprises employing the technologies, to understand their businesses, operations and marketing;
- Establish contacts with fabricators that could export the required equipment to participants' home countries;
- Exchange knowledge and experiences related to cotton and its by-products; and
- Promote South-South cooperation, including technology transfer, between India and the four African project countries.

Venue

ICAR-Central Institute for Research on Cotton Technology (CIRCOT) was established in 1924 and has its headquarters in Mumbai. CIRCOT is one of the constituent institutes of the Indian Council of Agricultural Research (ICAR), under the Ministry of Agriculture and Farmers Welfare, Government of India. CIRCOT's mandate is to carry out basic and strategic research in processing cotton and its agro-residues, development of value-added products and quality assessment of cotton. The Institute is also involved in capacity-building of its stakeholders through its skills development initiatives and offers incubation service for budding entrepreneurs. CIRCOT's laboratory is accredited by the National Accreditation Board for Testing and Calibration Laboratories (NABL and is functioning as a referral laboratory for cotton fibres.

CIRCOT gained international reputation through the Cotton Technical Assistance Programme of Government of India for Africa and is still actively involved in development of cotton sector in African countries. The Institute is the technical implementing agency in establishing the "Regional knowledge cluster cum training centre for post-harvest and ginning technology" at Bohicon, Benin. The institute is also organising the capacity-building programme on "Post-harvest processing of cotton and value addition to crop residues" for the African nationals under the India-Africa Forum Summit III that pivots on Human Resource Development for stronger Indo-African Cooperation.

This study visit was organized at the Ginning Training Centre (GTC) of ICAR-CIRCOT, located in Nagpur. The Centre was established as a regional unit of ICAR-CIRCOT in 1985, was first of its kind in Asia and remains one of 3-4 centres worldwide that undertake research activities and provide specialised training on ginning and value addition to cotton

by-products. The GTC has contributed immensely to modernising the Indian Ginneries under the Government of India's Technology Mission on Cotton. The Centre has pilot plant facility on double roller ginning technology, a scientific cottonseed processing unit, a particle board manufacturing unit and a pelleting plant, as well as fibre quality testing facility.

For more than 25 years, the GTC has served the stakeholders through training on ginning, value addition to cotton biomass; technical consultancy services to gin manufacturers and assistance in quality evaluation of cotton for breeders. The training curriculum is enriched by guest lecturers and study tours to machinery manufacturers, ginneries and value-added processors. The Centre has also become a hub for South-South cooperation on cotton value addition technologies: over the last 10 years, it has trained over 5,000 trainees from throughout India and Africa.

The GTC is situated on a campus of 30,000 square metres on Amravati Road in Nagpur. Popularly known as the Cotton or Orange City, Nagpur is located in central India and has good connections to New Delhi and Mumbai by air, road and rail. The Centre is located approximately 15 kilometres from Nagpur's Baba Saheb Ambedkar International Airport.

Participants

Sixteen delegates from Uganda, Zambia and Zimbabwe participated in the study visit. The delegates were selected by their governments, using guidelines provided by UNCTAD. They represented a broad range of stakeholders, including: farmers, farmers' associations, entrepreneurs, ginners, oil millers, seed breeders, researchers and policy makers. The group included four female participants.

Two UNCTAD staff members coordinated the study visit, in partnership with the ICAR-CIRCOT team. Representatives from two partner institutions – COMESA and International Trade Centre (ITC) – also participated in the study tour and assisted with coordination.

The full list of participants' names and designations can be found in Annex 2.

Structure of this report

The following sections summarize the programme from each of the five days of the study visit.

Last section provides the author's summary and expert recommendations, on how the Indian experience with cotton by-products can inform UNCTAD's technical cooperation project, as well as the broader development of cotton by-products in Africa.

The annexes include:

- The list of study visit participants (Annex 1)
- A list of suppliers of pellet stoves and pelleting and briquetting machines (Annex 2)
- The list of participants in the Business Meet, organized as part of the study visit, on 17 January 2019. (Annex 3)

All materials and documents mentioned in this report, presented or distributed during the programme are available on the study visit website.[3]

14 January 2019

Inaugural session

Location: Centre Point Hotel, Nagpur
Time: 10.00 a.m. – 12.00 p.m.

The study visit was formally inaugurated on 14 January at 10.00 a.m. The dignitaries present on the dais were:

- Dr. P. G. Patil, Director, ICAR-CIRCOT, Mumbai
- Mr. Kris Terauds, Economic Affairs Officer, UNCTAD
- Dr. M. K. Sharma, CEO, Bajaj Steel Industries, Nagpur

[3] Please visit: https://unctad.org/en/pages/MeetingDetails.aspx?meetingid=2047

- Mr. Matthias Knappe, Senior Programme Manager, ITC, Switzerland
- Mr. Thierry Kalonji, Director of Industries and Agriculture, COMESA
- Dr. V. M. Waghmare, Director, ICAR-CICR, Nagpur
- Dr. A. J. Shaikh, Former Director, ICAR-CIRCOT, Mumbai

The inaugural function began with playing of ICAR song and lighting of inaugural lamp by the dignitaries.

Dr. P. G. Patil, welcomed all the guests with bouquets of flowers and then delivered the welcome address and welcomed all the dignitaries and the participants from various African countries, invitees to the study visit. Dr. Patil highlighted the type of research and development work being carried out at ICAR-CIRCOT, Mumbai in the field of value-addition of cotton plant by-products and how it is beneficial in providing additional income to cotton farmers as well as in creating rural employment. He pointed out that the agricultural and socio-economic scenario of the African countries and India are similar and hence these technologies can be easily adopted in the African countries. He thanked UNCTAD, especially Mr. Kris Terauds, for their work in implementing the project on cotton by-products and for selecting Nagpur, India for the study visit of the African Delegates. He thanked all the African delegates for participating in the study visit and wished them a fruitful stay in Nagpur and assured them that they would learn new things and benefit from the study visit.

Mr. Kris Terauds too welcomed all the delegates to the study visit and thanked Dr. P. G. Patil for taking efforts to organize this study visit. He highlighted the objective of the programme on cotton by-products utilisation and informed the gathering about the progress made so far in the project. He informed that this study visit is arranged for the participants to have first-hand information about the potential technologies, to interact with the experts, on-site visits to various factories utilising cotton stalks for preparation of briquettes, pellets, particle board, compost, mushroom, as well as absorbent cotton wool plants, machinery fabricators, end users, among other. This exposure would enable delegates to see the process and clear all doubts and apprehensions about various aspects of the technologies. He assured the delegates that this study visit will give them confidence in establishing new businesses with the selected technologies. He wished the participants and the study visit a grand success.

Mr. Matthias Knappe presented the international cotton scenario and his experiences in cotton cultivation, ginning, cotton by-product value addition, etc. and how these technologies will be useful for farmers and in the generation of rural employment.

Mr. Thierry Kalonji gave a detailed presentation on the activities and programmes being implemented by COMESA in various African countries and their impact on the socio-economic conditions of those countries. He congratulated UNCTAD for taking up programmes for promoting cotton by-products value-addition in African Countries and hoped that it would become a grand success.

Dr. V. M. Waghmare, Director, Central Institute for Cotton Research (ICAR-CICR), Nagpur talked about various research and development (R&D) activities being carried out at CICR, Nagpur, such as the development of improved varieties of cotton, plant protection, biotechnological methods to solve cotton production problems, etc. and he invited all the delegates to visit CICR, Nagpur and thanked the organizers for inviting him for the function.

Dr. M. K. Sharma, CEO of Bajaj Steel Industries welcomed the delegates and presented a brief about the various machines manufactured by his company and promised the delegates that he would manufacture and supply all the machinery that are required for setting up factories in African countries. He also informed the delegates that Bajaj Steel has a branch office in Uganda. He invited all the delegates to pay a visit to his factories at Nagpur.

Lastly, Dr. A. J. Shaikh, former Director, ICAR-CIRCOT talked about the

importance of value addition of cotton plant by-products in providing additional income to farmers, rural entrepreneurship development, employment generation and in environmental protection.

He informed the delegates that he has been appointed as a contractor to write the report of the visit and he will be with them for all the five days. He requested delegates to approach him for any clarification or doubt. He thanked the United Nations for taking up the programme on value-addition to cotton plant by-products.

Dr. Sundaramoorthy, Senior Scientist proposed the vote of thanks and the inaugural session concluded with National Anthem.

Lecture on biomass briquettes and pellets

Location: Centre Point Hotel, Nagpur
Time: 12.00 – 12.45 p.m.

"India's Experience on Priority Cotton By-product Based Activity: Briquetting and Pelleting Technologies and Practices"

By: Dr. S. K. Shukla, Officer-in-charge, Ginning Training Centre, ICAR-CIRCOT, Nagpur

Dr. Shukla's presentation may be summarised as follows:

The properties of cotton stalks are akin to hardwood; hence, it can be used as an alternative to traditional hardwood.

In India, briquettes and pellets prepared from cotton stalks and other agro-residues have been accepted by many industries as viable alternative to coal/furnace oil for boiler fuel. As well as being a cheaper fuel than coal and furnace oil, biomass briquettes and pellets also reduce costs associated with ash disposal and pollution.

The bulk density, burning characteristics and thermal efficiency of agro-residues are improved by briquetting and pelleting processes.

Briquettes of 90-millimetre (mm) diameter, as well as pellets of 6-, 8-, 10- and 12-mm diameter are commonly manufactured in India for different industrial applications.

In India, more than 500 briquetting plants of 20 metric tonnes per day (TPD) capacity and an equal number of pelleting plants of 3 TPD to 20-40 TPD capacity are operational for the past 4-5 years.

Briquetting is very simple process, briquettes are prepared by feeding 10-15 mm cotton stalk chips at 10-12% moisture content through a briquetting press, which requires 90 horsepower (HP) of connected load and 6-8 workers per shift for its operation.

Pellets are easy to handle and burn easily in boilers because of their uniform shape, size and high energy density.

Pellets are utilised for power generation, industrial and large-scale heating purposes in many developed and developing countries. Biomass pellets have replaced commercial liquefied petroleum gas (LPG) cylinders in restaurants throughout India, as pellets cost about half as much as LPG and burn with smokeless flames, like LPG.

In pelleting process, up to 3 mm milled cotton stalks 12-14% moisture content are fed through pelleting machines. The power requirement, energy consumption and labour requirement for a pelleting plant depends on its production capacity. A pelleting plant of 20 TPD requires about 150 HP of connected load, 50-60 kilowatt hours (kWh) of energy and 6-8 workers per shift for its operation.

Dr. Shukla elaborated in detail about requirements of land, buildings, specifications of plants, machinery, initial investments, operating costs and economic benefits in establishment of a briquetting and pelleting plant in Africa.

Questions & answers

Time: 12.45 – 1.15 p.m.

1. **Question:** Cotton is a seasonal crop, so stalks are available for only 3-4 months. What other biomass can be used as raw material for briquettes and pellets?

   Answer: Any biomass that does not possess silica can be used for briquetting. In India, suitable agro-residues include soya bean, pigeon pea, bagasse, bamboo, groundnut and sawdust.

2. **Question:** Can cottonseed hulls be used as a raw material for briquettes and pellets?

   Answer: Briquettes/pellets can be prepared from a wide range of agro-residues, provided they are abundant and inexpensive. Cottonseed hulls are relatively costly, since there is demand for them to be used as animal feed. Cottonseed hulls are therefore not an economical raw material for the preparation of briquettes and pellets.

3. **Question:** What modifications are needed to convert a boiler to use briquettes or pellets as fuel?

   Answer: Gas- or oil-fired boilers need to be completely replaced with Fluidised Bed Combustion Boilers or Pulverised Fuel Fired Boilers. Boilers fired by solid fuels, such as coal or firewood, can be used with briquettes or pellets without any modifications.

4. **Question:** How much is the initial investment to establish a briquetting or pelleting plant in Africa?

   Answer: In India, a briquetting plant of 20 TPD capacity can be established for about US$ 70,000, while a pelleting plant of 20 TPD capacity requires an initial investment of US$ 400,000. The actual cost for establishment of such plants in Africa would be about 3 times the cost required in India.

5. **Question:** What are the prescribed standards for the physical and chemical properties of briquettes and pellets?

   Answer: In India, calorific value, ash content, moisture content, durability and fines are major parameters for determining the quality of briquettes and pellets. Minimum standards for briquettes and pellets are: calorific value of $\geqslant$3,500 kcal/kg, ash content $\leqslant$ 10%, moisture content $\leqslant$ 8%, durability $\geqslant$ 96% and fines $\leqslant$5%.

6. **Question:** What are carbonised or torrified briquettes and pellets?

   Answer: Torrefaction refers to roasting, slow and mild pyrolysis, cooking and high-temperature drying of the biomass in a temperature regime of between 200-300^{0}C under an inert atmosphere. It induces depolymerization and devolatilization of hemicellulose. Torrefied biomass is brittle and hydrophobic with improved physical and chemical properties such as grindability, storage stability, energy density and has the potential to significantly reduce the cost of transportation, storage, and downstream processing.

The torrefaction process involves pre-drying the shredded biomass by heating up to about 100^{0}C to evaporate physically bound water. Post-drying and intermediate heating are then carried out between 100 and 200^{0}C, removing chemically bound water as well as light organic fractions. Further heating will be carried out in the temperature range of about 200 to 300^{0}C, with adequate holding time for decomposition and release of various volatile particles with high oxygen contents. The remaining solid product, called torrefied biomass, is mainly comprised of cellulose and lignin and characterized by increased brittleness, hydrophobicity, microbial degradation resistance, and energy density. Torrefied briquettes and pellets prepared from such torrefied biomass.

7. **Question:** How can briquetting and pelleting plants and machinery be operated and maintained in African countries?

   Answer: The plants and machinery employed in briquetting and pelleting plants are not very sophisticated. They can be easily repaired and maintained by trained workers. ICAR-CIRCOT conducts regular skill development programmes for the operation and maintenance of briquetting and pelleting plants. In addition, suppliers of plants and machinery also impart the necessary operation and maintenance training for their products.

8. **Question:** Can a tractor front loader be used for loading and unloading of briquettes or pellets?

   Answer: At present, in India loading and unloading of briquettes and pellets is done manually. However, a tractor front loader could be used.

9. **Question:** How much cotton stalk can be collected per acre?

   Answer: As with seed cotton yield, it depends on a variety of factors. An average field in India produces 1 tonne of chipped cotton stalks per acre, with a moisture content of up to 12%.

10. **Question:** How much income can farmers earn from selling of cotton stalks?

    Answer: In India, a farmer earns about US$ 7.50/acre by selling of cotton stalks to end users.

11. **Question:** What is the approximate delivered raw material cost for a briquetting or pelleting plant?

    Answer: In India, a briquetting or pelleting plant needs to procure biomass raw material at US$ 35-40 per tonne to remain viable.

12. **Question:** What is the risk of the spread of pests or disease from stored biomasses in briquetting and pelleting?

    Answer: Pests and disease present in cotton stalks are killed or quarantined during chipping or shredding. Hence, there is no risk of the spread of pests or disease from stored ***chipped*** biomass in briquetting and pelleting plants.

13. **Question:** What are the main operational challenges for briquetting and pelleting plants?

    Answer: The major challenge in operation of a briquetting and pelleting plant is to ensure a reliable, inexpensive supply of suitable agro-residues from nearby areas. Secondary challenges include: a reliable supply of power, availability of skilled labour and access to end users.

14. **Question:** Can COMESA establish a demonstration plant for preparation of briquettes and pellets in ESA countries?

    Answer: COMESA will carry out a feasibility study after receipt of such proposals.

15. **Question:** What are the potential challenges to technology uptake in ESA countries?

    Answer: Biomass briquetting and pelleting technologies have been in operation for over 20 years in many countries. There are several suppliers in India and China. Hence, there should be no issue with technology uptake in ESA countries.

16. **Question:** Can you provide a list of suppliers of pellet stoves, briquetting and pelleting plants, along with their coordinates?

    Answer: The list of prominent suppliers is given in Annex 3 (the public version does not contain coordinates).

17. **Question:** What are the steps in supplying chipped cotton stalks to briquetting and pelleting plants?

    Answer: (1) Uproot the cotton stalk needs using prevailing practices. (2) Dry the stalks by sun in the field for 7-10 days. (3) Aggregate the stalks in a central field or location, no further than 5 km from where they were grown. (4) Chip the stalks using a tractor-operated chipper. (5) Transport the chipped stalks by truck to the briquetting or pelleting plant, no further than 40-50 km.

18. **Question:** Can briquettes of long sizes can be prepared?

    Answer: There are small openings in boilers through which briquettes are fed. Hence, it is not necessary to prepare briquettes of long sizes. Nevertheless, briquettes of any size can be prepared based on end user requirements, by modifying operating parameters and using appropriate binders.

19. **Question:** What are methods to control dust pollution in briquetting and pelleting plants?

    Answer: Dust pollution is a major problem in a briquetting and pelleting plants. It can be controlled using appropriate pneumatic conveying systems, cyclone separators, cyclone filters, etc. However, it involves substantial additional investment and operating costs.

20. **Question:** Are binders required in in briquetting or pelleting?

    Answer: In India, briquettes are manufactured without using any binder. For pellets, 5-6% sal seed cake is added to the mixture as a binder.

Visit to the ICAR-CIRCOT Ginning Training Centre

Location: Amravati Rd, Vayusena Nagar, Nagpur
Time: 2.00 – 5.00 p.m.

In the afternoon, the participants visited the GTC, Nagpur where the following processing units were demonstrated:

Particle board pilot plant

Dr. S. K. Shukla, explained and demonstrated in detail the process for manufacture of particle board from cotton stalks, which comprises chipping of stalks, drying of chips, hammering of chipped stalks into finer grade, separation of hammered raw material into coarser and finer grades, mixing of

hammered raw material with glue, mat formation, cold pressing followed by hot pressing to get the boards.

Actual demonstration of the board making process was given to the participants. Many questions were asked by the participants to understand the process properly.

Small-scale pelleting plant

CIRCOT experts demonstrated to participants the process of manufacturing pellets from cotton stalks on the pilot plant installed at the GTC. The burning characteristics of the prepared pellets was also demonstrated in a small stove.

Ginning plant

Participants also received demonstrations of various types of ginning machinery, such as cleaners, double roller gins, auto feeding mechanism, saw gin, etc. Merits and demerits of the different machinery types were explained to the participants.

Microbial process for degossypolization of cottonseed meal

The process of degossypolization of cottonseed meal by microbiological method was explained and demonstrated to the participants, which included multiplication and maintenance of microbial culture. This included a process for the nutritive quality enrichment in cottonseed meal by solid state fermentation. Participants asked many questions about the amount of gossypol reduction, protein content, effluent discharge, etc., which CIRCOT experts answered. The cost economics of the process was also explained.

Simple process for cultivation of oyster mushrooms on cotton stalks

The ICAR-CIRCOT technology for cultivating oyster mushrooms on cotton stalks was explained and demonstrated to the delegates. The process details precautions to be observed, quality and nutritive value of mushrooms as well as the cost economics of the process. Delegates received responses to their questions about the cultivation of mushrooms in higher temperatures, such as during the hot season. In summer, mushrooms can be cultivated under a poly house where temperature and humidity can be controlled. The group discussed the growing market in India and in other countries for fresh and dried mushrooms.

Scientific processing of cottonseed for oil extraction

Traditional oil expeller technologies crush the entire fuzzy cottonseed, recovering oil and cottonseed meal, the latter of which is fed to ruminants, such as cattle. In the expeller process, valuable by-products from the cottonseed are wasted, such as linters and hulls, and the quality of meal and the oil is also poor. Hence, CIRCOT is promoting the process of scientific extraction of oil and has installed a pilot plant for the purpose. Participants learned about the importance of the scientific extraction of oil and demonstrated the process on the pilot plant. The scientific process comprises seed cleaning, delinting, dehulling, oil extraction from the kernel, separation of meal, refining of oil for degossypolization and bleaching.

Participants wanted to know about the various uses of cotton linters, hulls, etc. Linters are used for the preparation of cellulose and cellulose-based derivatives and products, whereas hulls are used as animal feed after bio-enrichment. The economics of the process vis-à-vis the conventional process was also explained.

Participants also learned about the accelerated process developed by CIRCOT for preparation of bio-enriched compost from cotton stalks.

15 January 2019

Demonstration of cotton stalk collection in cotton fields

Location: near Katol, Nagpur district, Maharashstra
Time: 9.30 a.m. – 12.00 p.m.

Entrepreneurship development and setting up of an industry mainly depends on the supply of raw material in a sustainable, ready to use and cost-effective manner. Unlike bagasse, which is available at one place, i.e. from the sugar industry, in an easily transported baled form, cotton stalk is a different type

of raw material, as it is only available scattered in fields.

In India 10 years ago, there was no systematic supply chain and no agents available to collect, chip and supply chipped cotton stalks to processors. Hence, CIRCOT developed a logistic chain for collection, chipping, packing and transportation of cotton stalks at a competitive price.

The process was demonstrated to various farmer groups, NGOs, social organizations, industry people, etc. and is now widely used in cotton growing areas. This logistic chain enables industries to procure ready-to-use cotton stalk chips at their factory gate at an affordable price.

One such collection of cotton stalks was explained and demonstrated to the participants in a farmer's field at Katol, about 40 km from Nagpur. The entire process of uprooting of cotton stalks, cleaning, chipping and transportation was demonstrated to the participants. The participants were eager to know about:

- The quantity of stalks and chips that can be obtained from one hectare of land;
- The possible losses by way of moisture loss and transportation;
- The revenue farmers receive get from one hectare of cotton stalks;
- Costs to collect, chip and transport the stalks; and
- The agent's profit.

All these questions were satisfactorily answered and explained by the farmers group as well as the agent. Looking to the higher cost of transportation, it was suggested that the stalks should not be transported farther than 50 kilometres (km).

The participants had a first-hand interaction with the farmers and learnt about various problems and challenges faced in collection of cotton stalks and remedial measures to overcome them.

Visit to biomass briquetting plant, Aarohi Bio Coals

Location: Karanja, Wardha district, Maharashtra
Time: 1.00 – 3.00 p.m.

The participants were taken to Aarohi Bio Coals in Karanja (Ghadge), where the proprietor explained and demonstrated the production of briquettes using cotton stalks. The plant was of 1 TPD capacity and set up by a young engineering graduate. Apart from cotton stalks, the plant uses various other crop residues, such as soya stalks.

Participants sought several clarifications on topics such as: the effects on processing of moisture content, dust or dirt in the raw material; the suitability of rice straw as a raw material; seasonality of the business with respect to rains and harvesting; as well as marketing considerations, such as transportation to, and acceptance by end users.

The owner of the plant satisfactorily replied to all the above queries and assured the delegates that briquette making from crop residue is a viable and profitable venture. He added that he will soon expand the capacity of his plant by installing a second processing unit, as demand for his briquettes is increasing daily.

Visit to briquette end user, Pix Transmission

Location: Maharashtra Industrial Development Corporation (MIDC) Industrial Park, Hingna, Nagpur

Time: 3.00 – 5.00 p.m.

To demonstrate the performance of cotton stalk briquettes in an industrial boiler, the participants were taken to Pix Transmission, MIDC, Hingna Nagpur, an ISO 9000 company manufacturing rubber belts. Earlier, the company used fuel oil and coal to fire its boilers, fuels that were not economical and posed serious environmental problems. Hence, the company decided to convert to a biomass briquette-fired boiler.

The plant manager explained the various advantages he realised after shifting over to cotton stalk briquettes as fuel. The actual performance of cotton stalk briquettes in firing the boiler was demonstrated.

All the questions of the participants regarding the calorific value, cost advantage, smoke and ash generation, disposal of ash, etc. were answered to the satisfaction of the participants. After shifting to use of cotton stalk briquettes, the cost of boiler fuel has reduced by 40%, pollution in the form of smoke has reduced considerably compared to coal and oil and the ash produced is biodegradable, so more easily disposed of, in compliance with government regulations. The plant uses 20 metric tonnes (MT) of briquettes daily and is very satisfied with the fuel.

Visit to biomass pelleting plant, G. V. Saw Mill

Location: MIDC Industrial Park, Hingna, Nagpur
Time: 5.00 – 5.30 p.m.

Another important use of cotton stalk is in the processing of pellets, which can be used as household fuel and in restaurants as a substitute for coal. The process and machinery for making pellets from biomass is entirely different from briquette making, in terms of size, density and pre-processing of raw material, for example. To demonstrate the process and machinery for manufacture of pellets from biomass, the participants were taken to G. V. Saw Mill in Hingna, Nagpur, which manufactures pellets from various biomasses, such as cotton and soya stalks, as well as sawdust. They supply their pellets as domestic and restaurant fuel. Their capacity was about 1 TPD of pellets.

16 January 2019

Debriefing session

Location: Centre Point Hotel, Nagpur
Time: 9.30 - 10.00 a.m.

A debriefing session was organized on the morning 16 January. The participants were divided into two groups, coordinated by Mr. Kris Terauds and Mr. Matthias Knappe. The participants were asked to express their impressions and opinions about the previous day's visits and the potential for applying them in their countries. All the participants took part in the interactive session and enthusiastically expressed their opinions.

Lecture on degossypolization of cottonseed meal

Time: 10.00 – 10.45 a.m.

"Degossypolization of Cottonseed Meal"

By: Dr. V. Mageshwaran, Scientist, ICAR-CIRCOT Ginning Training Centre, Nagpur

Cottonseed is considered the "golden goose" as it provides four major industrial products *viz.,* linters, oil, meal and hulls. In India, about 12 million MT of cottonseed are produced annually. Cottonseed is processed by conventional and scientific method. By the conventional method, cottonseed is directly crushed for oil extraction in which only two products are obtained *viz.,* oil and meal. By the scientific method, cottonseed is processed systematically, and four products are obtained *viz.,* linters, hulls, meal and oil. Cottonseed meal is rich in nutritive properties, like soybean meal. Nevertheless, feed derived from cottonseed meal can only be fed to ruminant animals, due to the presence of the toxic enzyme gossypol and deficiencies in essential amino acids and lysine. Several chemical methods have been attempted for removing gossypol from cottonseed meal, such as solvent extraction, calcium hydroxide treatment, ferrous sulphate treatment, etc. These methods either deactivate free gossypol or convert it to the bound form. Microbial fermentation is a promising method, since biodegradation of gossypol occurs during the fermentation process, also the fermented cottonseed meal reduces bound and free gossypol and enriches the meal with enzymes, vitamins and other active substances.

ICAR-CIRCOT developed a microbial process of degossypolization which involves four steps, namely: mass multiplication of microbial cultures, solid state fermentation, drying and packing. The microbial strains used for degossypolization was *Candida tropicalis* and *Saccharomyces cerevisiae*. In mass multiplication, the microbial strains were transferred from petri plate to culture flask and then to culture drum. In solid state fermentation, the culture was mixed at the rate of 20% (10% each culture), initial moisture content maintained was 70% and incubated for 36 to 48 hours in plastic trays. In drying and packing, the fermented cottonseed meal was dried at 70° C for 3 to 4 hours, by which moisture content was reduced to 10% and packing was done in PP bags after cooling to room temperature. This step is usually done to deactivate the enzymes of

fermentation. The degossypolized and fermented cottonseed meal had 70-80% free gossypol reduction, 50-60% bound gossypol reduction, improved protein content and enriched lysine content. The replacement of 40% of soybean meal with fermented cottonseed meal had a better feed conversion ratio (FCR) among the different treatments in broilers (poultry) feed evaluation. The degossypolized meal is suitable for applications in feed industries such as poultry, fish and piggery. The solid-state fermentation developed is an eco-friendly process with zero effluent discharge. ICAR-CIRCOT microbial process of degossypolization has been filed for a patent. The technology was licensed to Sana Agro-Industries (Proprietor: Mr. Ifran Ali, Raichur) on non-exclusive basis.

Lecture on absorbent cotton wool

Time: 10.45 – 11.30 a.m.

"India's Experience of Absorbent Cotton Technology"

By: Dr. C. Sundaramoorthy, Senior Scientist, ICAR-CIRCOT, Mumbai

Dr. Sundaramoorthy's presentation was oriented towards the business prospects for absorbent cotton in the health and hygiene markets. In a cotton fibre, cellulose constitutes to around 88-94% of the dry weight of the fibre. The outer wall of the cotton fibre consists of oil, waxes and other cuticle layer that prevents cotton from absorbing water. In order to be categorized as an absorbent cotton, the product should satisfy the pharmacopoeia standards such as sinking time, water holding capacity, whiteness, moisture content, water soluble substances, ash content, etc. The technology for production of absorbent cotton involves removal of the external protective layer from the cotton fibre through the process of scouring and bleaching. The absorbent cotton is used in surgical dressing and cosmetic products and is popularly known as surgical cotton or cotton wool. The demand for absorbent cotton is growing due to population growth, expansion of health services and higher income levels. The government hospitals and large nursing homes and expanding public health services are the largest consumers of absorbent cotton products.

The production technology involves mechanical and chemical processes. The production of the absorbent cotton involves mechanical opening of the cotton, followed by chemical scouring and bleaching. The cotton is then washed to remove the chemicals and dried. Once dry, the cotton is fed through the following mechanical processing steps: fibre opening, lap formation, carding, rolling and then packaging. With finishing machines, absorbent cotton wool can then be processed into end products, such as zig zag cotton, cotton balls, cotton pledgets, which can find applications in the cosmetic and dental industries.

The cost of establishing the plant is determined by the volume of production and the selection of the machinery, i.e. new or used. The raw material that can be used in the process is any short-staple cotton with staple length less than 22 mm and micronaire of more than 5 micrograms per inch.[4] Comber noil, a by-product from the spinning industry, can also be used as the raw material to produce absorbent cotton. The production process requires considerable quantity of water and there is need for an appropriate effluent treatment plant as per environmental regulations.

[4] Micronaire is typically expressed as a ratio value, i.e. 5. The underlying unit is fibre weight per inch, expressed in micrograms.

Questions & answers

Time: 11.30 a.m. – 12.00 p.m.

Degossypolization of Cottonseed meal

1. **Question:** Why are ruminant animals resistant to gossypol?

   Answer: Ruminants have a specialized mechanism for detoxification of gossypol. The saliva of ruminants contains a complex of enzymes that can denature gossypol in cottonseed meal. Secondly, the ruminant microbes may detoxify gossypol during the digestion process.

2. **Question**: What is the detoxification mechanism in ICAR-CIRCOT's degossypolization process?

   Answer: In the ICAR-CIRCOT degossypolization process, two yeast strains are used, namely Candida tropicalis and Saccharomyces cerevisiae. These yeast strains release a complex of enzymes during the fermentation process and add protein and lysine to the cottonseed meal. The fermented cottonseed meal therefore contains less gossypol (bound and free), increased nutritive value and better digestibility. These yeast strains are not harmful and commonly used in baking and brewing.

3. Question: What were the different treatments tested during the laboratory evaluation of the performance of fermented cottonseed meal in the growth of broiler chicks?

   Answer: Although the presentation focussed on the best treatment, the presenter also reviewed all five treatments tested on broiler chicks, namely: (a) Only soybean meal (control), (b) 20% replacement of soybean meal with unfermented cottonseed meal, (c) 40% replacement of soybean meal with unfermented cottonseed meal, (d) 20% replacement of soybean meal with fermented cottonseed meal and (e) 40% replacement of soybean meal with fermented cottonseed meal. Among the different treatments, 40% replacement of soybean with fermented cottonseed meal had better feed conversion ratio and other growth performance of broilers.

Absorbent Cotton

1. **Question**: Can you provide a list of machines used in an absorbent cotton production line, along with their current price?

   Answer: The price of the machinery will vary by brand and whether you are purchasing new or used machines. CIRCOT experts suggested raising the same question during the visit to the absorbent cotton plant later in the programme.

2. **Question**: Can the bleaching process used for absorbent cotton also be used on other raw materials, such as banana fibre?

   Answer: The composition of the raw material plays a major role in determining the chemicals and process used for bleaching. Since cotton consists of more than 90% cellulose, hydrogen peroxide gives the desired result. Since banana fibre contains lignin, the same process cannot be used - a two-step process is required.

3. **Question**: Is there an eco-friendly process for the preparation of the absorbent cotton, minimizing the use of chemicals?

   Answer: Research efforts are ongoing to reduce the use of chemicals in the preparation of absorbent cotton. ICAR-CIRCOT has come up with an enzymatic process for preparation of absorbent cotton, in which scouring and bleaching are carried out through enzymes, greatly reducing the quantity of chemicals used in these two steps. The development of the enzyme-based process is at the stage of an industry-level scale-up trial.

4. **Question**: Can the same process be used on African cotton, which has a lower micronaire?

   Answer: A micronaire value of 4 and 4.5 will not have any significant impact on converting the cotton into absorbent cotton. African cotton, with its shorter staple length and lower micronaire value, can also be converted into absorbent cotton.

Visit to pellet machine fabricator, Vidarbha Sales

Location: MIDC Industrial Park, Hingna, Nagpur
Time: 2.00 – 3.30 p.m.

Participants were taken to Vidarbha sales, MIDC, Hingna Road, Nagpur, which is a leading fabricator of biomass pelleting machines. The participants were given a demonstration of pellet manufacture from biomass and the working of the machinery. The participants asked about the machinery's capacity, energy consumption, cost of production, and labour requirements. They also asked about the quality of pellets derived from different biomass raw materials and the comparative performance of biomass pellets relative to coal and other substitutes. The fabricator responded to all of the queries and assured participants that they will be able to supply pelleting and other machines to all African countries.

Apart from pelleting machines, the company demonstrated various other agro-processing machines it fabricates. The machines demonstrated were:

- Animal Feed cum Pellet Machine, capacity of 400-600 kilograms per hour (kg/h)
- Biomass Pellet Machine, capacity 150-250 kg/h
- Mini Rice Mill, capacity 100-150 kg/h
- Mixer machine, capacity 300-500 kg/h

Visit to end user of biomass pellets, Sai Ram Farsan (snack café)

Location: Pratapnagar, Nagpur
Time: 4.00 – 5.00 p.m.

After seeing the demonstration of pelleting machines, participants were keen to see the performance of biomass pellets as a fuel. CIRCOT arranged a visit to Sai Ram Farsan, a snack shop that has

shifted to biomass pellets from coal. The staff demonstrated the use of biomass fuel in their chulha (stove) to the participants and explained the various advantages in terms of fuel cost, reduced pollution and the absence of smoke. Participants asked various questions regarding calorific value and frying time of snacks on shifting to bio mass briquettes from coal.

17 January 2019

Debriefing session

Location: Centre Point Hotel, Nagpur
Time: 10.30 - 11.00 a.m.

A debriefing session was held on the previous day's programme i.e. presentations "degossypolization of cottonseed meal" by Dr. Mageshwaran and "India's Experience of Absorbent Cotton Technology" by Dr. C. Sundaramoorthy, as well as the visits to a pellet machine fabricator and an end user of pellets as fuel.

Business Meet

Time: 11.00 a.m. - 1.00 p.m.

The ICAR-CIRCOT Ginning Training Centre organized a Business Meet on 17 January the Centre Point Hotel, Nagpur, to facilitate interactions between the African delegates and Indian businesses involved in the cotton by-products value chain. Over thirty prominent stakeholders from briquettes, pellets, absorbent cotton, mushroom and machinery fabrication industries, as well as researchers, consultants, policy makers, ginners and end users interacted face-to-face with delegates. The business owners and other stakeholders shared their experiences and answered all the queries related to fabrication of machinery, establishing new enterprises, marketing of the products on national and international markets, among other topics.

At the onset, Dr. P. G. Patil, Director, ICAR-CIRCOT, Mumbai welcomed the participants and presented his introductory remarks. He informed delegates and stakeholders that ICAR-CIRCOT has been working for more than two decades on development of technologies for promotion of cotton by-products in India. Many industries have adopted CIRCOT technologies and methodologies, which yielded substantial benefits to them in recent past. Dr. Patil informed that several briquetting, pelleting and absorbent cotton plants are operational in India. Many industries have also started using biomass briquettes and pellets as alternative to coal that have reduced operational cost and at the same time reduced the air pollution and addressed the ash disposal issues.

Biomass briquetting, pelleting, absorbent cotton production and mushroom cultivation were the identified areas of discussion between the representative of various industries and delegates. The delegates asked several questions pertaining to establishment of biomass briquetting, pelleting, absorbent cotton production plants and mushroom cultivation facilities in their countries. In addition, power requirement, energy consumption, arrangement of raw materials, requirement of land, investment in plant and machinery, operational cost, etc. were also discussed during the Business Meet.

Visit to machine fabricator, Bajaj Steel Industries Ltd.

Location: MIDC Industrial Park, Hingna, Nagpur
Time: 2.00 - 5.00 p.m.

The participants were taken to Bajaj Steel Industries Ltd., an ISO 9001:2008 company with world-class engineering facilities in Nagpur for the fabrication of cotton ginning, pressing, delinting and decorticating machinery, as well as steel buildings, electrical panels, etc. In collaboration with its subsidiary Continental Eagle Corporation, Bajaj fabricates all four types of ginning machinery worldwide.[5] The company has six facilities in Nagpur and has a large team of trained and specialised professionals.

Dr. M. K. Sharma, CEO of the company welcomed all the delegates and showed them a video explaining the company's various departments and activities.

After that the participants visited four factory sites, observing the infrastructure and facilities involved in fabricating different types of machines..

Participants also saw the quality control laboratory, where machines and parts are regularly checked before dispatch to the customers.

The participants were very impressed with the scale and technology of Bajaj Steel Industries and sought various clarifications on a variety of topics. Dr. M. K. Sharma informed the delegates that Bajaj Steel Industries has a branch in Uganda and regularly ships machines to African countries, so would have no problem helping African clients set up new plants.

[5] Single roller, double roller, saw and rotary knife.

Visit to machine fabricator, Precision Tooling Engineers

Location: MIDC Industrial Park, Hingna, Nagpur
Time: 5.30 - 6.00 p.m.

Several years ago, cotton researchers, seed breeders, farmers and others in India faced problems with ginning small samples of cotton, either to find out the ginning out-turn or for recovering ginned seeds to undertake sowing or breeding trials. At the time, they normally resorted to hand ginning methods to separate lint from seed. This was a very tedious and time-consuming method. CIRCOT, in collaboration with Precision Tooling Engineers, have designed and developed small laboratory-sized ginning machines, including the single roller gin, Lilliput gin and cloy gin, which are portable, easy to operate and cost effective.

A visit was arranged to Precision Tooling Engineers, Nagpur to explain and demonstrate these small ginning machines. Mr. Bhatt, CMD of Precision Tooling Engineers explained and demonstrated the operation of all the small ginning machines. These machines created lot of enthusiasm and interest in participants and they asked several questions about capacity, delivered cost of machines to African countries, power consumption, maintenance, etc. Mr. Bhatt replied to all the queries and informed the delegates that these machines are very popular in India and abroad. The production capacity of the machines ranges from one kg/h to 5 kg/h and they are easy to maintain. He also informed that they have also supplied these machines to United Nations for supply to Afghanistan.

18 January 2019

Debriefing session

Location: Centre Point Hotel, Nagpur
Time: 9.30 – 10.30 a.m.

The delegates had an interactive session with CIRCOT experts to answer any questions related to the technologies and businesses they had seen. For example:

- Many delegates wanted to know whether the process of degossypolization of cottonseed meal is part of an oil extraction chain, or a separate process. CIRCOT experts explained that degossypolization of meal is not part of the chain and must be done separately.
- Some delegates wanted to know about quality requirement of raw material for processing absorbent cotton. CIRCOT experts explained that absorbent cotton can be made from any type of cotton if it meets the pharmacopeia quality standards. However, meeting fibre length requirements is very important.
- Some delegates wanted to know about the marketability of mushrooms, briquettes and pellets. In all three cases, awareness needs to

be created by supplying free samples to users and explaining the product's benefits.

Visit to absorbent cotton plant, Surgical Cotton Industries

Location: MIDC Industrial Park, Butibori, Nagpur district
Time: 11.00 a.m. - 12.00 p.m.

The delegates were taken to Surgical Cotton Industries absorbent cotton plant in Butibori, which was about 30 kms from Nagpur. The Director of the plant explained and demonstrated the working of the plant which comprised of digesters (large vats) for kiering and bleaching of cotton, washing of cotton, drying, opening of kier bleach cotton, cleaning of bleached cotton, mat formation, packing etc. The capacity of the plant is about 1 TPD of surgical cotton. The company was using mainly comber noil as the raw material.

The delegates asked several questions about the quality of the absorbent cotton from comber noil, as compared to coarse cotton (raw cotton lint). The owner of the plant replied that if the final product meets the Indian pharmacopeia standards, they will have no problem about raw material. However, he informed that comber noil is more economical compared to coarse cotton.

Participants wanted using second-hand machinery to prepare absorbent cotton and the maintenance problems with old machinery. The Director of the plant informed that very old machines, i.e. 30 to 40 years old, should be avoided due to maintenance costs. However, 10- to 15-year-old machines are economical and reliable for use.

Participants also pointed out that the labour requirement in his plant is quite high. The Director explained that automated plants require less labour, but more capital investment. Since he targeted the low-cost absorbent cotton market, he built his plant from used machines and without automation. As for the sterilisation of absorbent cotton, the Director informed that if it is destined for surgical applications, it must be sterilised.

Visits to machine fabricators

Location: MIDC Industrial Park, Butibori, Nagpur district
Time: 12.00 – 2.00 p.m.

Later, the participants were taken to Sanghavi Industries and Vineengineer Enterprises, two engineering and machine fabrication plants in Butibori. Representatives from the two companies had invited the group earlier in the morning for these unscheduled visits. Both companies had all the facilities to manufacture different types of machines as per specifications.

Valedictory session

Location: ICAR-CIRCOT Ginning Training Centre, Nagpur
Time: 4.00 p.m. – 5.00 p.m.

The valedictory session was organised in the meeting hall of Ginning Training Centre of ICAR-CIRCOT at Nagpur.

The guests of honour were Dr M. K. Sharma, CEO of Bajaj Industries Ltd. and Mr. Wairale who is organising large scale cotton stalk collection for briquettes and pellets. Other dignitaries present on the dais were Mr. Kris Terauds, Dr. S. K. Shukla, Dr. V. G. Arude and Dr. A. J. Shaikh.

Dr. Shukla, Principal Scientist and Office-in-Charge of the Ginning Training Centre, welcomed all the delegates and guests and then briefed the delegates about details of the training programme study visit organised during last five days, highlighting the importance and logic of lectures followed by visits to relevant industries. Participants gained first-hand information about the technologies and interacted with business owners to answer their questions and gain confidence. He hoped that all the delegates benefitted from the programme and then requested one representative from each country to express their feedback.

Statements from country representatives

Mr. Alberto O. B. from Uganda thanked ICAR-CIRCOT and UNCTAD for organising such a useful programme. He said that his country would be interested in technology of briquette and pellet making from cotton stalks, as well as degossypolization of cottonseed meal. However, for the adoption of cotton by-products in his country, he expressed the need for stronger government policies to raise awareness about their benefits and to support the establishment of new value added processing businesses.

Mr. Washington Mumbvekeri of Zimbabwe expressed gratitude to UNCTAD and ICAR-CIRCOT for organising the study visit on by-product utilisation in such an effective manner. Attending the study visit had added to his knowledge. He informed the group that he and his colleagues from Zimbabwe will work after their return to encourage stakeholders to set up cotton by-product industries.

Mr. John A. Mulongoti of Zambia thanked the organisers for the study visit and for arranging a comfortable stay for the

delegates. He expressed his country's interest in degossypolization technology, pellets and absorbent cotton.

Mr. Kalonji from COMESA thanked ICAR-CIRCOT and UNCTAD for organizing the study visit in such an excellent manner. He was pleased by the way the delegates were received at various factories and allowed to take photographs of plants and machinery,. As per his experience, it is rare for factory owners to accord such freedom to visitors. It underlined CIRCOT's strong relationship with industry.

Mr. Matthias Knappe thanked UNCTAD for giving him an opportunity to be the part of the programme and thanked ICAR-CIRCOT for the excellent manner the study visit has been organized. He identified briquetting and pelleting as the technologies with the most potential to be adopted in African countries and urged COMESA to take the lead in convincing governments to establish industries based on these technologies as they stand to benefit the farmers.

Ms. Marjorie Chaniwa expressed the view that implementation of cotton by-product industries will be successful only if there is a strong relationship between industry and research organizations. She thanked the organisers for giving her an opportunity to be part of the study visit.

Certificate Distribution and final remarks

ICAR-CIRCOT distributed certificate of participation to all the participants.

Dr. M.K. Sharma thanked the organisers for inviting him and the delegates for visiting Bajaj Steel's factories. He promised that, as and when required, Bajaj Steel Industries will manufacture state-of-the-art machinery for utilization of cotton by-products.

Dr. S.K. Shukla proposed a vote of thanks. He thanked all the delegates for participating in the study visit and showing keen and sincere interest in learning. He thanked all the guests and Mr. Kris Terauds for choosing Nagpur and India as the location for the study visit. At the end, he thanked Dr. P.G. Patil Director, ICAR-CIRCOT for his guidance and all his colleagues for assistance in successful organization of the study visit and finally to ICAR for its kind permission to organize this study visit.

SUMMARY AND RECOMMENDATIONS

Cotton cultivation in recent years in India and other Afro-Asian countries has become less remunerative due to high cost of inputs, low productivity and fluctuating price. Although some progress has been made in recent years in India, the country's average yield has always remained far below the world average. Most farmers are unable to make a reasonable living out of cotton cultivation.

Seized with such concerns, ICAR-CIRCOT trained its research efforts on utilisation of by-products of cotton, which have the potential to not only open new vistas for industrial activity but also bring additional income for the farmer whose interest in cotton farming would thus stay undiminished.

ICAR-CIRCOT in the last few decades, has been engaged in extensive study on the utilisation of cotton by-products such as linters, seed hulls, oil and meal, cotton stalk, etc. and have been able to gather voluminous basic information on these components and developed processes for industrial utilisation of some of them. Notable among them are a range of physico-chemical and bio-chemical processes for the utilisation of linters, hulls, meal, cotton stalks etc. for production of various products like, cellulose powder, cellulose derivatives from linters, bio enriched animal feed from hulls, animal feed from degossypolized meal, composite boards, pulp and paper, briquettes, pellets, bio-enriched compost, edible mushrooms etc. from cotton stalks. Besides fetching additional income to farmer, the above technologies provide additional benefits, including: removal of stalks from the field, precluding the carryover of pests; providing additional raw material to industry; creating job opportunities; and protecting the environment.

The success of any enterprise will depend on the entire cost economics and some of the following factors:

- Cost of raw material in a usable form, delivered to the industry gate
- Development of economic logistics for collection, chipping and transportation from field to industry, as well as proper storage
- Cost of production
- Simplicity of the processing technology
- Availability of market for the products
- Level of capital investment
- Cost and quality comparison with similar products available in the market

Keeping all the above factors in mind, as well as the agricultural scenario in Zimbabwe, Uganda, Zambia and the United Republic of Tanzania – the availability of raw materials in these countries, availability of skilled labour, marketing, etc. – it is recommended that the following technologies may be considered for establishing value-added industries based on cotton plant by-produce.

- Briquetting, pelleting, mushroom cultivation and composting from cotton stalks.
- Degossypolization of cottonseed meal by solid state fermentation for animal feed.
- Absorbent cotton/ surgical cotton from ginning waste or unspinnable coarse cotton.

These technologies are simple, easy to adopt, low investment, simple plant and machinery, no maintenance problems, viable at low capacities, easy to meet raw material requirements and above all, products can find easy market and will have no competition. Thus, CIRCOT technologies are suitable for the upcoming projects in African countries.

Key success factors

Logistics for cotton stalk collection

The most successful model developed by ICAR-CIRCOT involves uprooting, and drying cotton stalks in the field; aggregation and stacking of stalks at a central location, no farther than 5 km from the harvesting point; manual cleaning; chipping using a tractor driven chipper; and transportation by truck of the chipped biomass to a briquetting/pelleting plant within a maximum radius of 50 km. On average about 1.0 tonne to 1.3 tonnes of chips are obtained per ha of land under rainfed conditions.

Transporting cotton stalks farther than 5 km before chipping and farther than 50 km after chipping would not be economically feasible. On average the cost of chipped cotton stalk, delivered to the briquetting/pelleting plant was Rs. 2,500/- (US$ 35.70) per tonne for a raw material with 10% moisture. The cost economics in different African countries must be worked out.

Storage of cotton stalks

ICAR-CIRCOT conducted several experiments on storage of cotton stalks, such as: in unchipped or chipped form; in open, shaded or covered conditions. Observations were made after a month on any changes to the chemical composition and quality of the biomass raw material.

It was found that:

- Unchipped stalks stored in the open were most susceptible to degradation by insects; and
- Chipped stalks stored in shaded or covered conditions suffered no insect damage and preserved their chemical composition and quality characteristics.

Pesticide Residues in Cotton Stalks

ICAR-CIRCOT conducted a study to estimate pesticide residue on cotton stalks. Samples of stalks with and without bark were collected from the field and were analysed for the presence of pesticide residues using standards from the Association of Official Agricultural Chemists (AOAC International). The estimation was carried out using gas chromatography / mass spectrometry (GC/MS) instruments with an Electron Capture Detector (ECD). Interestingly, the study did not reveal presence of any pesticide residues on the cotton stalks.

Enforcement of Safety Regulations

A lot of dust, hazardous fumes and toxic effluents are generated in briquetting, pelleting and absorbent cotton plants, which can cause health hazards to workers. It is therefore essential that, along with supplying technical knowledge to entrepreneurs, governments enforce safety standards for workers and hazard mitigation measures.

Action plan for the success of the project

For success of all the efforts made in the project, the following action plan is recommended.

1) Begin by establishing a few supply chain centres in clusters of cotton growing areas for the collection, chipping and supply of cotton stalks from field to factory. Initially these centres will require financial assistance from government or donors. They can serve as demonstration centres, to eventually be taken over by private entrepreneurs as a rural enterprise.
2) Build awareness among entrepreneurs, NGOs, financial institutions, government agencies and other stakeholders about the utility of cotton stalks as a raw material for producing briquettes, pellets, compost and edible mushrooms.
3) Build awareness among farmers that they can earn an additional 5% of income from selling their cotton stalks.
4) Establish demonstration plants for manufacturing of briquettes, pellets, compost and mushroom, which can serve to build awareness, train prospective entrepreneurs and demonstrate the quality of the products to end users.
5) Gather market information and conduct consumer trials to inform marketing plans and change consumption patterns in favour of briquettes and pellets.
6) Create awareness among manufacturers of animal feed about the quality and usefulness of degossypolized cottonseed meal.
7) Provide free surgical cotton samples to consumers and hospitals to generate market demand.

Finally, the project should ideally help identify and motivate entrepreneurs in each country to take the work forward, submitting proposals to establish cotton by-product industries. Once industrial consumption of cotton stalks and other agro-residues picks up, farmers would earn additional income and have the incentive to grow more. Industrial growth, rural employment and conservation of forest resources, would be other national benefits to follow.

Annex 1: List of study visit participants from African countries

Table 1 - List of participants from African countries

#	Name	Nationality	Designation
1	Mr. Ogen Bob Alberto	Uganda	General Manager(Research), West Acholi Cooperative Union Ltd.
2	Mr. Atuheire Godfrey Korinako	Uganda	Research Office, Uganda Industrial Research Institute
3	Mr. Ssekisambu George Wilson	Uganda	Director, Ssingo United Investment Ltd.
4	Mr. John Kennedy Bukenya	Uganda	Plant Breeder, Cotton Development organization
5	Mr. John A. Mulongoti	Zambia	Director, Ministry of Commerce, Trade and Industry
6	Mr. Hans Yamba	Zambia	Principal Economist, Ministry of Commerce, Trade and Industry
7	Mr. Carrivorious Simasinti	Zambia	Manager, Premier Cooperative
8	Ms. Brandin Phiri	Zambia	Farmer
9	Mr. Michael Banda	Zambia	Committee Member, Cotton Association of Zambia
10	Ms. Christina Phiri Banda	Zambia	Vice Chairperson, Cotton Association of Zambia
11	Mr. Meredieth S. Muchena	Zimbabwe	Cotton Specialist, Zimbabwe Farmers Union
12	Mr. Tararama Gutu	Zimbabwe	Director, Cotton Processing Company
13	Mr. Washington Mubvekeri	Zimbabwe	Head, Cotton Research Institute
14	Mr. Collen Kabudura	Zimbabwe	Economist, Ministry of Agriculture
15	Ms. Marjorie Chaniwa	Zimbabwe	Operations Manager, Cotton Company of Zimbabwe
16	Ms. Adeva Gwenzi	Zimbabwe	Officer, Zimbabwe Farmers Union

Table 2 - List of staff from UNCTAD and partner institutions

#	Name	Nationality	Designation
17	Mr. Stefan Csordas	Austria	Associate Economic Affairs Officer, UNCTAD
18	Mr. Kris Terauds	Canada	Economic Affairs Officer, UNCTAD
19	Mr. Matthias Knappe	Germany	Senior Programme Manager, ITC
20	Mr. Thierry Kalonji	Democratic Republic of the Congo	Director of Industry and Agriculture, COMESA

ANNEX 2: LIST OF SUPPLIERS OF PELLET STOVES, PELLETING AND BRIQUETTING MACHINES

Sl. No.	Items	Suppliers
1	Pellet stoves	**Abellon Clean Energy Limited** **Head Office** Sangeeta Complex, Near Parimal Railway Crossing, Ellisbridge, Ahmedabad - 380006, India. www.abelloncleanenergy.com **Ghana Office** F 744/3 1st Otswe Street, South La Estates, Osu – La Beach Road, P. O. Box, GP 18983,Accra, Ghana
		First Energy Thermax House,14, Mumbai Pune Road, Wakdewadi, Pune, Maharashtra, India 411003
		Vidarbha Sales W-27, MIDC, Hingna Road, Near PIX Transmission, Nagpur - 440016, MS, India
2	Briquetting plants	**ECOSTAN India Private Limited** Ludhiana Malerkotla Road, K.M. 23, Opp. Toll Plaza, V.P.O. Lehra, Dist. Ludhiana, Pin – 141118, Punjab (India)
		Jay Khodiyar Group Samrat Industrial Area, Street No.2, Nr. Jay Khodiyar Machine Tools, Gondal Road, Panchsheel Wadi, Rajkot, Gujarat 360004
		LEHRA Group of Companies Ludhiana – Malerkotla Road, Opposite BP Petrol Pump, Near Shanti Tara College, V.P.O. JAGERA 141117 (Punjab), INDIA
		Radhe Engineering Company D-111, Rajdoot Industrial Area, 5 - Umakant Pandit Udhyognagar, Near Mavadi Plot, Rajkot, Rajkot, Gujarat 360004
3	Cotton stalk chipper	**Maharashtra Engineering**, Lakhani Plot, Bodwad Road, Behind Wankhede Petrol Pump, Malkapur
		***Sardar* Engineering** Office. 7/C, Wanjra Industrial Area, Pili Nadi, *Kamptee Road*, Nagpur - 440 026, Maharashtra, India
		Vidarbha Sales W-27, MIDC, Hingna Road, Near PIX Transmission, Nagpur - 440016, MS, India
4	Pelleting plants	**Vidarbha Sales** W-27, MIDC, Hingna Road, Near PIX Transmission, Nagpur - 440016, MS, India;

Annex 3: List of participants in Business Meet, 17 January

No.	Name and coordinates	Remarks
1	Shri Lalit Kalantri General Manager (Sales), M/s. Bajaj Steel Ind. Ltd., Nagpur	Manufacturer of Ginning and Pressing Machinery
2	Shri Mrinal Mishra Vice President, M/s. Bajaj Steel Ind. Ltd., Nagpur	Manufacturer of Ginning and Pressing Machinery
3	Shri K. G. Bhat Proprietor, M/s. Precision Tooling Engineering, MIDC, Nagpur	Manufacturer of Small Ginning and Lint/ cotton opener Machineries
4	Dr. J. F. Agarwal Principal, Saibaba Institute of Technology, Bhadravati	Researcher
5	Dr. M. S. Kairon Former Director, ICAR-Central Institute for Cotton Research (CICR), Nagpur	Cotton farmer and Researcher
6	Shri G. H. Wairale Former GM, Maharashtra State Cotton Federation, Nagpur	NGO: Agroplus foundation, CITI,CDRA ,Nagpur
7	Shri Ankit Jalan, Managing Partner, M/s. Tanmay Industries, Nagpur	Manufacturer of Briquettes
8	Shri Naresh Jain, Proprietor, Jain Gases, Nagpur	Manufacturer of Briquettes,
9	Shri Shekhar Wankhede Proprietor, M/s. Swastik Renewable Energy Pvt. Ltd, Nagpur	Manufacturer of Briquettes, collection of cotton stalks
10	Shri Gaurav Charade, Proprietor, M/s. Pratiksha Enterprises, Butibori, Nagpur	Collection of cotton stalks
11	Shri Ankush Kale Proprietor, M/s. Shrikrishna briquetting Industries, Tivsa,	Manufacturer of Briquettes
12	Shri. Avachat, Proprietor, Briquetting plant, Rehaki	Manufacturer of Briquettes
13	Shri Dishant Kataria Proprietor, M/s. Katariya Agro Pvt. Ltd, MIDC, Hingna, Nagpur	Manufacturer of Briquettes and Pellets
14	Shri Prakash Rao Proprietor, M/s. Sun Trading, Nagpur	Manufacturer of Briquettes
15	Shri Ishan Gotmare Proprietor, MIDC, Hingna, Nagpur	Manufacturer of pellets
16	Shri Sanjay Nagulwar Proprietor, M/s. V-care Surgical, Butibori	Manufacturer of Surgical cotton
17	Shri Prakash Rathi, Proprietor, M/s. Rathi Chemicals, Bhandra Road, Nagpur	Manufacturer of Surgical cotton
18	Shri Anil Chouk Proprietor, M/s. Vidarbha Sales, Nagpur	Manufacturer of pellets and house hold machineries, pellet stoves
19	Shri Sanjay Kshirsagar Proprietor, M/s. Vidarbha Sales, Nagpur	Manufacturer of pellets and house hold machineries, pellet w stoves
20	Shri Yogesh Gojrekar Manager (Sales), M/s. Vidarbha Sales, Nagpur	Marketing of pelleting machines
21	Shri Avinash Tarekar 8055012449	Collection of biomass
22	Shri Gopal Shivhare Proprietor, M/s. Nagpur Fuels, Nagpur	Distributor of pine and other agro residue pellets, Pellet stove and collection of cotton stalks
23	Shri. Gaurav Charade Proprietor, M/s. Pratikha Enterprises, Butibori, Nagpur	collection of cotton stalks
24	Shri Ninad Darvekar GM (Sourcing), M/s. Pix Transmission, MIDC, Hingna, Nagpur	Utilisation of Briquettes as boiler fuel as alternative to coal
25	Shri Ram Ghate Service Engineer, M/s. Uster Technologies, Nagpur	Service Engineer of HVI, Cotton and Yarn testing equipment
26	Shri Rajesh Dubey, Divya Agrotech	Consultant
27	Shri Sambhaji D. Borkar, Progressive Mushroom Producer M/s. Sambhaji Mushroom farm, Sindhi Railway, Wardha	Mushroom production farm
28	Shri Vinod Patil M/s. Sambhaji Mushroom farm, Sindhi Railway, Wardha	Mushroom production farm
29	Shri T. R. Patil Progressive Cotton Farmer, Nagpur	Cotton farming
30	Shri Rahul Bharatwar Cotton Inspection Services, M/s. CIS laboratory, Nagpur	Cotton Trader and Cotton testing laboratory
31	Shri Sharad Pinjarkar Ginning Consultant, Nagpur	Consultant for ginning and pressing factory and oil mill
32	Shri Anirudhha Parsatwar Proprietor, Aarohi Bio Coals, Karanja (Ghadge), Nagpur	Manufacturer of Briquettes