

The ICAC Recorder

International Cotton Advisory Committee



Table of Contents

• Editorial.....	2
• Boosting Yields in Africa, What Technologies Work?	3
• The Challenging Task of Evaluating Impact: Compaci's Evaluation Framework and Summary of Results	16
• Promoting Cotton By-Products in Eastern and Southern Africa: Lessons from a United Nations Technical Assistance Project.....	19
• Progress of Ethiopian Cotton Producers Toward Sustainability	24



Editorial

The June 2019 volume of the ICAC RECORDER contains the final set of articles to complete the year-long, four-volume special series on 'This Time for Africa'. I enjoyed every bit of my time working on the articles, because they reflect hope. This edition has four articles. Prof. Serunjogi and his colleagues make an incisive analysis on almost all interacting effects in the cotton production system to lay down a road map to boost yields in Africa. Their article is a comprehensive synthesis of thoughts on plant breeding, production practices, pest management, agronomy principles, and policy factors that can pave the way for high yields of superior fibre with sustainable practices. The article concludes by reiterating the need for an international cotton research institute under the Consultative Group on International Agricultural Research (CGIAR) system.

Mr. Kris Terauds describes the UNCTAD project initiatives on 'Promoting cotton by-products in Eastern and Southern Africa.' The project enhances resource capacities in Africa and pursues new opportunities for adding value to cotton by-products such as seeds and cotton stalks with the objective of increasing income opportunities for farmers and entrepreneurs, especially in rural areas for an overall resilient cotton sector. Mr. Terauds concludes that *"there is potential to establish profitable processing businesses in Africa for selected cotton by-products, such as absorbent cotton wool and biomass briquettes and pellets ... Generating additional income in the cotton value chain can help increase seed cotton prices paid to farmers and revive their incentives to grow more cotton."* Ms. Daniela Jann and Mr. Tobias Bidlingmaier outline the results of a mega-project under the Competitive African Cotton Initiative (COMPACI), which was operational in 12 countries from 2009-2016, into two phases with the overall objective of promoting sustainable cotton cultivation and the improvement of living conditions of smallholder farmers in Africa. The collaborating partner-companies of COMPACI trained almost one million smallholder farmers in sustainable agricultural techniques in sub-Saharan Africa, reaching out to 25-30% of the cotton farmers. The project succeeded in influencing 80% of COMPACI farmers to apply good agricultural practices. Dr. Zerihun Desalegn describes the pilot interventions for sustainable cotton production, made in a project titled 'sustainable cotton initiative Ethiopia (SCIE)' that established a business case for production of good quality cotton through sustainable means to increase profitability.

The four articles in this volume and all the articles in the previous three volumes are analytical and express ideas with promise for cotton in Africa. In these articles, researchers examined the challenges and problems, and articulated their views on the possible strategies for a positive change. The majority of the articles surmised that low yields and underutilisation of cotton and its by-products are the biggest challenges in Africa.

About 88.0% of raw cotton is exported from Africa. Rather than export lint, if the fibres are processed locally, African cotton has the potential to provide additional employment to 5.5 million people and generate export revenues worth US\$30 billion to US\$90 billion. The underutilised cotton by-products have a potential to generate revenues worth about US\$400 million and generate additional employment. Unfortunately, Africa has neither exploited cotton fibres nor the cotton by-products for value addition, employment or trade revenues. It is not as if there were no attempts made. There have been many projects and several great initiatives to improve the livelihood of cotton farmers and the African cotton sector. The fact remains that despite all efforts, the yields in Africa remain the lowest in the world and have been stagnant over the past 40 years.

Are the yields destined to be low forever? The answer depends on whether Africa is willing to experiment and try. An African researcher once remarked to me that *'cotton yields can be increased only with hi-fi technologies and Africa cannot afford them'*. Interestingly, yields across the world have increased by simply improving the 'harvest index', which hinges on 'source-sink' relationship of water and nutrients.

Improving the harvest index involves simple changes in varietal breeding and suitable agronomy to ensure good sunlight and efficient use of water and nutrients by the fruiting parts of the plant and less waste in unproductive biomass. These concepts have been reinforced in the arguments made in several of the articles in the four volumes.

These ideas are expected to provide a background for African researchers to experiment and try for a change — a change for the better. Indeed, where there is a will, there is a way. Africa needs the scientific will and an enabling political environment for a breakthrough to happen.



Boosting Yields in Africa, What Technologies Work?

Serunjogi Lastus Katende, Jolly K. Sabune (Mrs.) and Ben Anyama, Cotton Development Organisation (CDO), P.O. Box 7018, Kampala, E-mail: cdo@cdouga.org and

Michael A. Ugen, National Semi-arid Resources Research Institute (NaSARRI), P.O. Box 56 Soroti, E-mail: director@nassari.go.ug

Full Paper of a Presentation made at the 6th Breakout Session, during the 77th Plenary Meeting of the International Cotton Advisory Committee (ICAC), Abidjan, Ivory Coast, 2nd – 7th December, 2018

Introduction

The ICAC estimates for the 2018/19 cotton season show that out of the 75 cotton-growing countries, lint yields ranged between 118 kg/ha in Chad to 1,848 kg/ha in Australia. The top eight countries (in descending order) with the highest yields in the world in 2018 were, Australia, Israel, Turkey, China, Russia, Mexico, Brazil and Greece (Figure 1). The average yield of these countries was 1,562 kg/ha. In 2018, 20 countries in sub-Saharan Africa produced 1.44 million tonnes of lint from 4.43 million hectares at an average yield of 324 kg/ha. However, 68%

of the production came from 60% of Africa's area that is concentrated in five countries in West Africa: Benin, Mali, Burkina Faso, Cote d'Ivoire and Cameroon. In sub-Saharan Africa, South Africa topped the list in yields with 955 kg/ha followed by Ethiopia at 657 kg/ha, Cameroon at 473 kg/ha, Cote d'Ivoire at 452 kg/ha and Benin at 418 kg/ha. All other countries in Africa harvested less than 350 kg/ha.

However, the estimates on lint yields for Uganda, as of November 2018, were 363 kg/Ha, while the actual yield in the 2017 season was 340 kg/Ha, (CDO Annual Reports and www.cdouga.org).

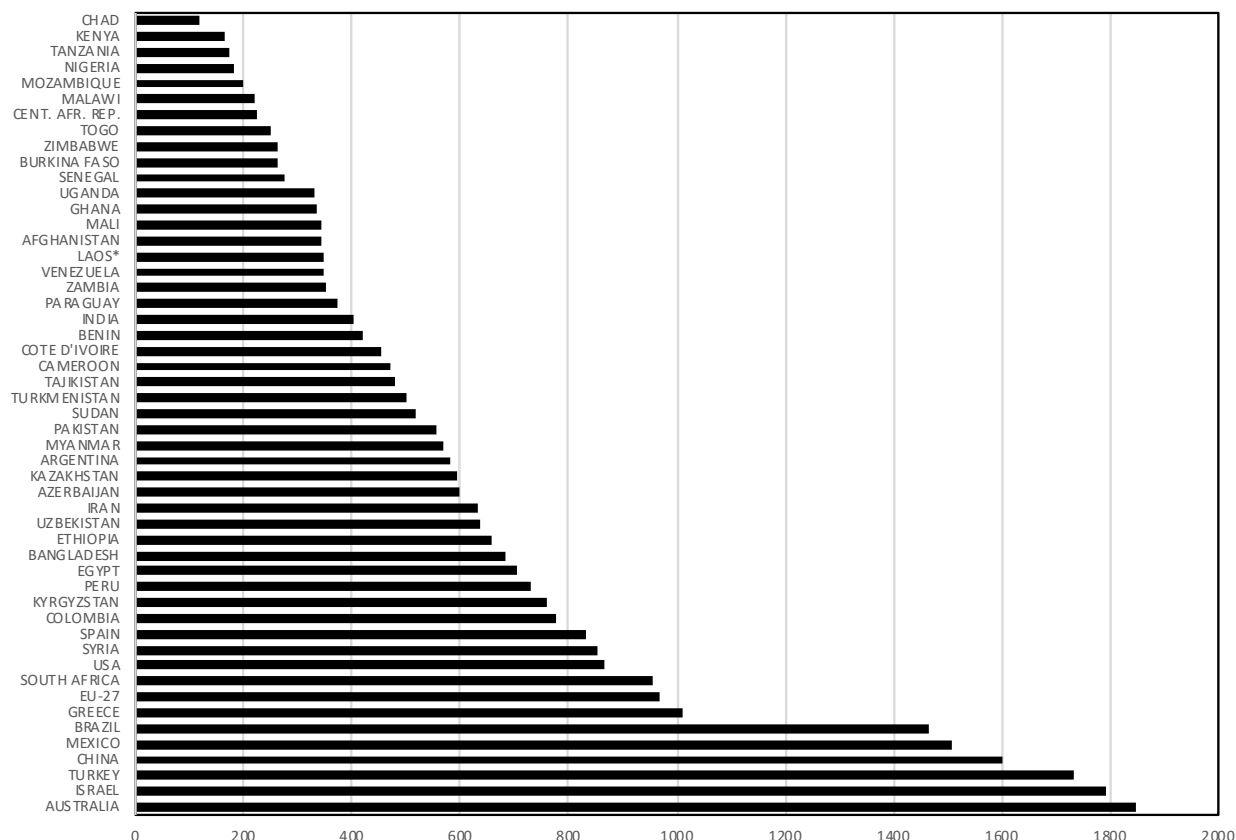


Figure 1. Yield (Kg/ha) in main cotton growing countries 2018

In 2018, the lowest cotton yields in the world (range 118 kg/ha to 274 kg/ha; average 222 kg/ha) were realised from eleven countries in Africa — Burkina Faso, Tanzania, Nigeria, Zimbabwe, Togo, Mozambique, Malawi, Chad, Central African Republic, Kenya and Senegal — which cultivated cotton in a total area of 2.1 million hectares to produce only 465,310 tonnes of lint. Thus, It is clear that the cotton yields in Africa are dismally low compared to any other part of the world.

The ICAC, (2018c), state: ‘The average lint yields in Africa have been about 350kg/ha for more than three decades, and this must change’. While attributing the low African cotton production to low yields, CIRAD (2018) stated that ‘African cotton yields are among the lowest in the world, yet the continent has huge production potential’.

Cotton, which is by far the most important renewable raw material in the global textile industry, is predominantly grown by more than 3.5 million smallholder farmers in Africa. Also, the cotton sector is cited as one of the most important sources of rural employment and cash income in Africa (CHA, 2018).

The importance of cotton in African countries’ economies was further elaborated upon by CIRAD 2018, as ‘more than two million rural households in Sub-Saharan Africa rely on cotton production to earn their livings. Overall, 37 out of 55 African countries produce cotton (Figure 2), where in many of those countries, cotton is a critical crop which accounts for significant proportions of GDP or total exports. However, taken as a whole, Africa is relatively a small global producer; it contributes only 6.0% to the global cotton production by using 13.5% of the global



Figure 2. Cotton Growing Countries in Africa

cotton acreage. Clearly, the main reason for low African cotton production is low yields’.

It is therefore important to identify the factors responsible for low cotton yields and identify means and strategies to increase the yields in Africa. High yields from optimised input usage can enhance sustainability of the cotton supply chains, contribute to the welfare of African populations in the cotton sectors and have the potential to improve African economies in general. This paper examines the practical technological options to boost yields in Africa. Needless to emphasise, increasing cotton yields in Africa is invariably expected to go hand in hand with increases in fibre lint quality.

Determinants of Cotton Yields

Genetic, agronomic and environment components and their interactions play an important role in yields. There is a need to diagnose the critical factors responsible for low yields in Africa to identify pragmatic solutions that can lead to yield enhancement.

The main factors that determine cotton yields are;

- The genetic potential of a variety used in cotton production,
- Genetics and the environment (GXE) interaction, and
- Production technologies or agronomic practices that can actualise the genetic potential of the variety.

A Variety’s genetic potential for higher yield and for any other economically important traits such as plant protection or drought-resistance or herbicide-tolerance or input-use-efficiency can be improved either through conventional breeding or through bio-tech based technologies. There is, however, a group of comparatively contemporary or new and or innovative types referred in this paper as ‘neo-technologies’.

The environmental components on the other hand, include; rainfall amounts and patterns, soil fertility, temperature regimes, insect pests, diseases, nematodes and their epidemics; inter alia.

Diagnosis of the precise interaction effects between production technologies and the environments on yields and likely causes of low yields could serve as the basis to design effective strategies to enhance yields.

Low yields in Africa are most likely due to the following two factors:

- Failure of the cotton sector to develop appropriate technologies suitable for facilitating high performances of the cotton crops under the prevailing environments, and
- Failure in ensuring formidable adoption and appropriate application of the technologies by the cotton farmers.

The desirable increases in cotton yields and fibre quality through interaction effects between the cotton genotypes and production inputs were described by Serunjogi *et al*; (2014) with emphasis on the need for balanced input use in cotton production. Proper use of inputs during the critical stages of cotton crop production, as recommended by the research and development (R&D) sector, would play a crucial role in achieving desired magnitudes of lint yields and fibre quality. Sabune and Serunjogi, (2017) described increases in yields as benefits realised under facilitated Cotton production technology transfer regimes in Uganda. Production technologies should not remain closeted in R&D shelves; there is an urgent need for developing comprehensive but simple technology transfer mechanisms in Africa.

Boosting Cotton Yields in Africa -What Technologies Can Work?

Cotton production conditions in Africa

While the cotton yields have been stagnant and low for decades in Africa, observations have been made on the existence of suitable production technology and conducive environments for high yields in the same production domain.

The ICAC in 2018 perceived this coexistence of low yields, despite favourable conditions as a 'paradox', since African cotton production conditions comprise of the following factors:

Highly suitable weather for cotton, with good sunshine and rainfall;

Good soils and probably better than many other parts of the world where cotton is grown;

New technologies which have been developed in Africa that reach many farms; and

Hardworking farmers applying their best management skills for higher production.

Therefore, it would be pertinent to ask; 'What are the prohibitive constraints responsible for the prevalent low cotton yields in Africa despite the existing favourable opportunities? How can these constraints be solved?' and 'for boosting yields in Africa-what technologies could work?'

British Cotton Growing Corporation (BCGC)

The prevailing conducive cotton production conditions listed by the ICAC (2018) which are expected to favour high cotton yields in Africa date back to the early cotton research which was supported in some African countries by the erstwhile rulers, for example, the activities of the British Cotton Empire in Africa (Figure 3). These were succeeded later by the British Cotton Growing Corporation (BCGC) activities (Anon. 2018, b) that contributed substantially in

shaping the present-day production technologies in most cotton growing countries in Africa. A few examples are listed below:

- The Namulonge Cotton Research Station was established by the BCGC in 1949 in Uganda. The research station which was first set up as Kawanda Research Station, was later transferred to Bukalasa, (now an Agricultural College), and then eventually to Namulonge. All the three sites were located in the Central Region of Uganda. Namulonge eventually became the Headquarters of BCGC activities in Africa, until 1972, when the corporation staff left in a hurry under the difficult law-less rule which prevailed in Uganda then. Other Cotton research programmes were started earlier in the 1930's, at Serere in North Eastern Uganda, (Serunjogi *et al*; 2001), to cater to the cotton production technology requirements of the semi-arid Northern and Eastern regions.



Figure 3. The British's Cotton Corporation's Director of Research Station, Dr. Hutchinson, with workers examining cotton plants for signs of diseases at Namulonge, Uganda in the 1950s (www.iwm.org.uk).

- The successes of the production technology then, in effecting high cotton yields, are attributable to exchanges of; information on production technologies, breeding materials, and of germplasm stocks, between the African countries under the auspices of BCGC. For example, the Albar cotton Stocks which were desired for their resistance to the then notorious Bacterial Blight disease caused by *Xanthomonas axonopodis malvacearum* in East Africa then, are known to have originated from selections made out of a variety called 'Allen' obtained from Nigeria. The Nigerian Allen in turn had been imported from Uganda in 1912. It is, however, believed that while in Nigeria, Allen had naturally out crossed with a perennial cotton species,

Gossypium hirsutum race *punctatum*, which conferred to Allen the genes for resistance to bacterial blight. The resultant resistant accessions became to be known as 'Albar', where 'Al' stands for 'Allen' and 'bar' for 'blackarm/bacterial blight resistance' (Serunjogi *et al*; 2001 and Orawu *et al*; 2017). The Albar stocks laid the foundation of the current breeding programs for the development of cotton varieties in Africa, especially in Uganda and continue to play a crucial role in breeding programmes mainly, because of their resistance to Bacterial blight disease, coupled with adaptability to wide ranges of environmental variations in production areas, and good fibre quality.

- In essence, the efforts in the current African cotton research programmes continue to build upon the achievements that were made under the times of BCGC and its affiliated Institutions on cotton research, which operated elsewhere in non-BCGC benefitting African countries then. Some 'schools of thought', however believe that there is a need to renew and revamp African cotton research at the technical level (Seine and Bachelier, 2017, a & b) to achieve a breakthrough. This is to enable African cotton growing countries to gear up to the new global requirements on yields and fibre qualities under competitive cotton value chains, a scenario which is different from the one which existed during the times of BCGC.

The current cotton production technologies in Africa

The prevailing cotton production technologies in vogue are similar in many of the African countries, that inherited a common research structure of the BCGC. The technologies are categorised under:

Varietal improvement

The varieties developed in Africa were developed, tested and selected across intended production areas, for characteristics of; early maturity periods, improved seed cotton and lint yields (complemented by high Ginning Out-turn, GOT), high quality fibres, resistance to pests e.g. selecting for high density plant hairiness which confers resistance to sucking pests like the jassids (*Empoasca* sp), resistance to diseases and for tolerance to drought.

Seed multiplication and processing

Varietal development and seed production are based on organised procedures standardised by the ICAC. During the 72nd ICAC plenary meeting held in Cartagena,

Colombia in 2013, the ICAC member countries approved the standardisation of nomenclature of cotton planting seeds for adoption by member governments. The nomenclature comprises the following levels: Breeders', Foundation, Certified, Registered and Commercial seeds (ICAC 2013). The seeds are processed, de-linted, treated with chemicals for pest and disease resistance, packed and labelled to indicate varietal name, targeted season of planting, agronomical packages on spacing for desired plant populations and on pest management.

Agronomic packages

Crop production practices include details on land preparation, seed bed preparation, proper sowing date, soil moisture management, planting geometry, soil fertility management, weed management, regulating plant growth and picking. Crop residue management is followed to ensure that residues are incorporated into the soil in a timely manner to provide nutrients to the ensuing crop. Sowing dates are decided based on the monsoon predictions to ensure adequate soil moisture for seedlings and at least 500 mm of rainfall for the crop (Serunjogi *et al*, 2001). Land preparation, seed bed preparation, sowing and weeding operations are carried out using minimal mechanisation using oxen drawn implements, (Figure 4).



Figure 4. Using Animal Draft Power for Cotton Seed Bed Preparations in Uganda

Integrated Pest Management (IPM)

Insect pests and diseases are managed using IPM strategies. These approaches include, *inter alia*, the use of biological control, biopesticides and chemical insecticides based on economic threshold levels to ensure that the pest control actions have least disruptive effects on the naturally occurring biological control organisms (Sekamatte *et*

al, 2003). The IPM options also expect farmers to follow recommendations of proper pesticide dilution, follow safety precautions, use appropriate spray technologies of knapsack, motorised and or tractor mounted sprayers with appropriate nozzle types.

Biotech cotton

Several African countries have streamlined the official biosafety procedures to regulate the assessment and approval of bio-tech cotton for economically important traits such as resistance to insect pests, diseases and herbicides.

In August 2018, Nigeria became the seventh African country to officially grant approval of production of bio-tech cotton. Thus, Nigeria followed the six African countries — South Africa, Sudan, Swaziland, Kenya, Malawi and Ethiopia — that approved bio-tech cotton production under their national laws before (ISAAA, 2018).

Kranthi (2018a), described the status on government approvals on use of bio-tech cotton in African countries on trait basis. So far, insect-resistant biotech Bt-cotton had been approved in six countries in Africa — South Africa, Burkina-Faso, Sudan, Nigeria, Swaziland and Ethiopia. In addition, herbicide tolerant trait was also approved in South Africa. Malawi, Kenya and Cameroon were conducting multi-location trials of Bt-cotton while Cameroon was considering herbicide tolerant traits for approval.

In Uganda, the 'National Biotechnology and Biosafety Bill 2012' was tabled in the Parliament in October 2017. It was referred back to the Parliamentary Committee on Science, Technology and Innovation for refining. The refined Bill was re-tabled and passed by the Parliament in November 2018. It had been renamed as 'Genetic Engineering Regulatory Bill, 2018' and was mandated to provide a regulatory framework for safe development and application of biotechnology and release of Genetically Modified Organisms (GMOs), Anon (2018a). The new Act had to be assented to by the President of Uganda by the end of February 2019 before being fully operationalised under the Uganda Laws, Anon 2019.

ICAC Perspectives to Boost Yields in Africa

- In 2018 and 2019, the ICAC released three special issues of 'The ICAC Recorder' which contain views and ideas of various stakeholders in the global cotton fraternity on how to increase cotton yields in Africa, (ICAC 2018b, ICAC 2018c, ICAC 2019). In the September, 2018 issue (ICAC 2018b), the Editorial gave an excellent summary on the low yields which had marred the African cotton production. The yields had stagnated at 350kg/ha in the last three decades,

in comparison to over 1,500 kg/ha of lint in five high cotton yielding countries: Australia, China, Mexico, Brazil and Turkey.

- The editorial emphasised the need for a change in plant architecture and planting geometry for high plant density in Africa and India, as an idea that could lead to a break-through in yields. The proposed planting geometry could enable the crop to enhance its utilisation efficiency of sunlight, water and inputs and produce high yields in a short time with less inputs and low cost. These ideas were based on the proofs derived from success stories Australia, China, Mexico, Brazil, Turkey and USA.
- The editorial brought out the need to identify the basic principles which underpin the required technological changes towards increasing the yields. The principles would then be assimilated and used in the development of concepts, strategies and technologies which had to be tested and validated in the local environments of adoption in Africa.
- Some of the above observations were also captured in an article titled 'Perspectives on Cotton Research and Ideas for Africa-Proceedings & Recommendations of the XIV Meeting of Southern & Eastern Africa Cotton Forum (SEACF)' that represented the views expressed in the SEACF Meeting held at Harare, Zimbabwe during 4-6 July 2018, with a theme 'Global best practices for cotton yield enhancement in Africa' (ICAC 2018b).
- Following is an abridged list of the recommendation that emanated from the SEACF meeting:
 - Breeding cotton varieties 'efficient' on the use of nutrients and water and with compact architecture to enable mechanisation of production operations.
 - More support to cotton research and strengthening cotton research institutions.
 - Formulation of demand driven production technologies, with farmers' participation for increasing their uptake.
 - Design farmer-participatory strategies to protect the cotton crop from weather vagaries and climate changes.
 - Government and private agencies facilitation of farmers' access to crop protection technology against pests and diseases.
 - Organised production and availability of good quality certified planting seeds.
 - Support schemes for sustainable availability of inputs such as fertilisers, pesticides and machinery.
 - Sustainable cotton brands under the rain-dependent systems to fetch higher prices in global markets.

- Promotion of conservation agriculture to enhance soil health vis-à-vis the existing conventional tillage systems which are in operation in Africa and responsible for soil degradation.
- Technology transfer training programmes for farmers' education and awareness.
- Among the other comprehensive and 'must-read' papers related to ideas for increasing cotton yields in Africa published in the September 2018 ICAC Recorder (ICAC 2018b), include the ones authored by Farid Uddin *et al*, and Sabesh.
- Furthermore, in the same issue of the September 2018 ICAC Recorder (ICAC 2018b), Kranthi (2018b) gave invaluable insights into how compact cotton plant architectures and canopy management would lead to increased yields in cotton in Africa. He explained the merits of scenarios in Australia, Brazil and USA wherein breeders aim to develop compact architecture cultivars that retain an optimum of 15 to 20 bolls per plant but with a planting density of 80,000 to 110,000 plants hectare. High yields of 1,000 to 2,500 kg/ha of lint are obtained in such cases. Kranthi advocated for the need of adopting compact cotton architecture and canopy management for increasing cotton yields in Eastern and Southern African countries (Section on the Authors' Views to Boost Cotton Yields in Africa, of this Paper). He described the different scenarios in Africa and India where plant breeders have been developing plant types that produce high number of bolls of up to 80 to 150 bolls per plant. Such plants need wide spacing for their tall and wide plant growth habits. While they produce many bolls, such cotton cultivars take longer time to maturity and if terminated prematurely, they result in low yields. Their 'critical windows' (flowering to boll formation stages) range from 80 to 120 days in comparison to the high-density short duration crops of 40 to 80 days. Thus, the cotton crop in Africa or India needs more water and nutrients during the long critical windows to provide high yields.
- In the December 2018, 'Special Issue' of 'The ICAC Recorder' Hezhong Dong and Michel Fok (2018) described how Light and Simplified Cultivation (LSC) techniques could lead to increased yields in small-scale farming systems in Africa. The technique includes use of small-scale agricultural machinery, materials and equipment designed to reduce or replace manual operations but simplified in comparison to heavy machinery used in intensive cultivation technologies, such as those deployed in China. The techniques include single-seed precision sowing machines, control of vegetative branches without pruning, one-time fertilisation, fertigation and maturity grouping for unique harvests.
- In the December 2018 issue of the ICAC Recorder (ICAC 2018c), Blaise Desouza gave a comprehensive description on how adoption of the 'Best Management Practices (BMPs)', under small-holding and limited resources category of farming, could increase cotton yields in Africa. Conservation Agriculture (CA) is one of the major components of BMP which holds the key to improving productivity. CA revolves around three basic principles namely; minimising tillage, including a permanent cover and crop rotation. It was emphasised that achievement of merits of CA need testing of the technologies on a regional basis i.e. successful CA technologies in a given country may not directly or necessarily work in another country without confirming their suitability in the new environment. There is need to understand the local situation (including soils and climate), and tailor the CA practices to suit the local conditions.

Authors' Views to Boost Cotton Yields in Africa

Since the conventional technologies and existing production systems have not been successful in obtaining high yields in Africa (ICAC, 2018b), it is proposed that efforts be made towards promotion of neo or innovative technologies, that have been developed and found effective in African research stations. There is a need to use appropriate technology transfer mechanisms to take innovations from the labs into the land. These new approaches should be backed by appropriate legal and institutional arrangements and supplemented by collaborations across research and initiatives' programmes in Africa. Efforts should also be made periodically to review the effectiveness of the technologies that are currently in use, and also propose new strategies for cotton research in Africa wherever appropriate.

Use of 'Neo-innovative' and Affordable Technologies

Biopesticides

Formulation of affordable, safe and effective bio-pesticide extracts from locally available plant materials like trees' and herbs'; leaves, barks, fruits and kernels or seeds has been attempted in Uganda. A Bio-pesticide Laboratory was constructed and inaugurated in August 2017, www.cdouga.org, (Figure 5). It is strategically located at the National Semi-arid Resources Research Institute (NaSARRI). The NaSARRI (www.nasarri.go.ug) holds the mandate for cotton research under the broad research programmes of the National Agricultural Research Organisation (NARO), (www.naro.go.ug). The Bio-pesticides Lab was constructed under the auspices of the Cotton 'Technical Assistance Programme' Cotton-TAP-Africa -India, with the support of the Government



Figure 5. Training of scientists in the Bio-pesticide Lab at NaSARRI Serere, Uganda in August 2017

of India towards strengthening the cotton supply chains, (www.cottontapafrika.org), in African countries. The TAP phase-1 was operational from March 2012 to 2017 in Seven African cotton growing countries, namely Benin, Burkina Faso, Chad, Mali, Nigeria, Uganda and Malawi.

The Bio-pesticide Lab at NaSARRI is already formulating bio-pesticides from Uganda native trees and shrubs such as *Lantana camara*, Neem (*Azadirachata indica*), Mahogany sp, *Khaya senegalensis* and *Moringa olifera* tree species. The laboratory has also a facility for testing soil samples to determine fertiliser requirements for cotton production in the different production zones. The Bio-pesticide laboratory is expected to be upgraded to commercial production level of the bio-pesticides so as to serve other cotton producing countries in the region.

Gayi *et al*, (2016) showed that bio-pesticides such as 'Nimbecidine', which are extracts from Neem tree; leaves, bark, fruits, roots and from seeds kernels, and Khaya extracts from seeds and barks, provided better control of cotton bollworms and significantly higher yields of seed cotton than their counterpart synthetic pesticides in Uganda. These bio-pesticides were recommended in Uganda for the control of cotton bollworms, namely, American bollworm (*Helicoverpa armigera*), Spiny bollworm (*Earias insulana* and *Earias biplaga*) and Pink bollworm (*Pectinophora gossypiella*), (Gayi, *et al*; 2017).

Isolates of a fungus *Metarhizium anisopliae* have been derived at the NaSARRI Bio pesticide Laboratory. The fungus is known to be effective in the control of major pests, especially the Lepidopteran insects, which include: Fall army worms, Cotton Bollworms and Maize Stem borers. Pure cultures of the fungus have been obtained at the Lab. The cultures are being tested in the lab and

field conditions to identify the most potent strains that can be multiplied and released for use in cotton crops in Uganda, (Gayi, 2019. *Pers com*).

Biological control

The use of biological control refers to the use of living organisms for the control of insect pests and harmful pathogens in cotton. Some of these techniques include the use of beneficial insects or natural enemies, which predate on cotton pests e.g. the Black Ants *Lepisiota spp.*, which were found effective in the control of major insect pests of cotton in Uganda (Ogwal, *et al*; 2003). Other beneficial insects on cotton include; Ladybird beetles, common wasps, praying mantis, assassin bugs (*Pristhesancus sp.*), wasps (*Trichogramma* and *Telenomus sp.*) and spiders. Biological agents also include the Nuclear polyhedrosis viruses, *Metarhizium*

anisopliae, *Beauveria bassiana*, *Isaria sp.*, and *Verticillium lecanii* that infect insect pests of cotton (Gayi, *et al*; 2017). Modalities for mass rearing of such biological agents should be developed to enhance sustainability of crop protection through low cost and environmentally friendly approaches.

Bio-fertilisers

The use of biofertilisers greatly enhances soil health in the eco-friendliest manner. Many species micro-organisms such as *Rhizobium*, *Azotobacter* and phosphate solubilising bacteria (PSB) such as *Pantoea agglomerans* or *Pseudomonas putida* have been commonly used in cotton ecosystems either as inoculants for leguminous crops, or application to seeds and soils to enhance soil fertility. Intercropping cotton with nitrogen fixing legumes like Soybeans (*Glycine max L.*) (Serunjogi *et al*; 2002), or common beans *Phaseolus vulgaris* (Elobu *et al*; 1995) inoculated with nitrogen fixing *Bradyrhizobium japonicum* or appropriate *Rhizobium* species greatly enriches the soil with nitrogen. Several strategies have been used to design crop-legume intercropping systems to ensure significant nitrogen fixation without any competition of the legume crop with cotton. While enhancing the soil health, many such legume crops provide food security and additional income. Apart from intercrops, cover crops and green manure crops are grown before the crop is sown or between cotton rows and incorporated into the soil later to enhance fertility. Those tested and recommended for use in cotton in Uganda include; digging Macuna beans *Macuna pruriens*, Wild or Mexican sunflower, *Tithonia diversifolia*, (Figure 6), herbs into the soil before planting (subterranean application) or mulching the cotton seed



Figure 6. Plants of *Tithonia* sp, (left), and leaves applied in trenches between Cotton Rows, (right) to be incorporated into the soil



Figure 7. *Tithonia* treated cotton crop at flowering (left) and at boll opening stages (right)

bed with either species' herbs between the rows i.e. surface application (Elobu *et al*; 2016). Increased seed cotton yields were realised with application of *Tithonia* leaves in trenches 5-10 cm from the cotton rows and about 10 cm deep, where the *Tithonia* leaves were buried at a rate of 1000 kg/ha of leaves (Figure 6). *Tithonia* sp leaves are known to be rich in Nitrogen, Phosphorous, Potassium, Calcium and Magnesium nutrients which contribute to the growth of cotton plants. Plots treated with *Tithonia* gave up to 2,245 kg/ha of seed cotton compared to 1,796 kg/ha of the controls without *Tithonia*. This represented a 25% increase in yield over control (Figure 7) with improvements in fibre quality (staple length and strength) which would thus fetch better prices for the lint especially in International markets. Additionally, there were increased residual soil nutrients such as Phosphorous and Potassium which could benefit the subsequent crops like; Finger Millet (*Eleusine coracana* (L) Gaertn), Maize (*Zea mays*), and Groundnut (*Arachis hypogaea* L.) in the crop rotations (Elobu *et al*; 2017).

Growth regulators

A few growth-regulating chemicals have been tested and some were found to be useful in boosting plant growth and for insect pest management. In Uganda a chemical called 'Vitazyme' was tested on cotton for three seasons. Vitazyme is known to be a cotton root vigour inducing chemical. It contains highly active bio-stimulating agents from natural plant sources that lead to luxuriant plant growth. Its active ingredients include B-vitamins, folic acid and other un-quantified growth regulators (Syltie, 1985). Vitazyme was tested in combination with the already approved commercial seed dressing chemical 'Cruiser Extra Cotton' used for control of seed borne diseases, like bacterial blight, and known for enhancement of root vigour. Vitazyme was found to be effective in boosting vigor of cotton roots which enabled deeper penetration and wider coverage of soils for tapping of water and nutrients by the cotton crops. In addition to improving plant vigor in the study, Vitazyme led to enhanced seed cotton yields and

fibre characteristics compared to the controls. The best results were from the 5% Vitazyme concentration for seed dressing, coupled with one foliar spray on cotton plants using 1 l/ha of Vitazyme at full bloom (Elobu *et al*; 2018). Chemicals with novel modes of actions were tested in IPM programmes. In Uganda, a product known as 'Celite 610' (trade name: 'Deadzone') is being tested on cotton (Figure 8). Celite 610 is a 'Mechanical Insecticide', that adheres to the insect cuticle and adsorbs to their lipid layers or cuticular wax. It thereby creates pores in



Figure 8. Pest control with a Novel Mechanical Pesticide, "Deadzone". Chemical residues on the sprayed leaves (left) and the resultant healthy crop (right)



Image: Keshav Kranthi, ICAC

Figure 9. Canopy Management

the cuticles which leads to desiccation and death of the pest. It is manufactured from Diatomaceous Earth which consists of Diatoms, a type of hard-shelled algae deposited on prehistoric fresh water lakes and marine estuaries. Deadzone was found to be very effective in control of pests such as Lygus, Leafminers, Mealy Bugs, Pink bollworms and Tobacco Thrips *Frankliniella fusca*, (Jiwei Zhu *et al*; 2016).

Canopy management

The use of cotton vegetative growth through canopy management techniques by reducing vegetative branching leads to effective 'source-sink' channeling of nutrients and photosynthates into fruiting branches, fruiting points, flowers and into developing cotton bolls thereby enhancing the harvest index (ratio of seed cotton versus

a) Mechanical Plant canopy management;

Restricting height to 60-90cm by manual clipping of apical nodes and a short season of 140 days, giving 15-20 bolls per plant with removal of vegetative branches and leaving only 9-10 fruiting branches: (b) Application of PGR; for a cut-out on apical growth at 4-5 fruiting branches above white flower. The PGR application also restricts internode length to 4-5 cm and offers retention of 80% of the flower squares and 60-70% of the bolls.

plant biomass). Some of the techniques include application of Plant Growth Regulator (PGR) such as 'Pix', (Mepiquat Chloride) on the cotton crop to arrest further vegetative growth of the cotton terminal points (Elobu *et al*; 1997). Similar effects can also be achieved by mechanically de-topping the main stem apical or terminal buds. The above treatments are applied after boll setting stages, so as to divert photosynthates and nutrients to the developing fruiting points and cotton bolls. Canopy management techniques which were described by Kranthi, (2018b, 2018c), include; breeding for short season varieties of about 150 days or less to maturity, restricting plant heights to 60 – 90 cm by manual de-topping or by use of PGR and/or removal of non-productive (vegetative) or monopodial branches (Figure 9). Canopy management is considered as an important technique for high yields in

high density planting of over 111,000 plants/ha as in top cotton yielding countries, as opposed to less than 16,000 plants/ha with tall and wide and bushy cotton plants in African cotton farms. Breeding cotton varieties with reduced vegetative branches has been successful in some breeding programmes for example in Uzbekistan. These compact varietal architectures, which are generally referred as 'zero monopodial plants' enable



Figure 10. Cotton Plant Varietal Architecture: (Left) Vegetative Wide Branched and (Right) Zero or Compact Branchless Types.

high plant population. For example, with 'zero monopedal plants', close cotton plant spacings of 76.5 x 8cm have been attained in Australia. This is in comparison with spacings of 90 x 60 cm which are in use in India and Africa. In addition, compact cotton plants make it easy for mechanisation of operations (Figure 10) of weeding, chemical applications and picking (Kranthi, 2018b).

Institutional Support

A few institutions have been active in Africa offering alternative technological approaches, dissemination strategies and to enhance the sustainability of cotton value chains. Some institutions and programmes on Initiatives have come up with objectives of developing new approaches and insights into cotton production and entire cotton value chains in Africa. Their main priority is to obtain high cotton yields in sustainable manners. The Cotton Expert House Africa (CHA), is a private sector-driven non-profit organisation (www.cotton-house-africa.org) aimed at supporting sustainability in the African cotton and textile sectors under the changing market environments. The CHA supports production of cotton under certification 'standards' like, Cotton made in Africa (CmiA), Better Cotton Initiative (BCI), and Fairtrade cotton. These standards are recognised by major textile manufacturers, brands and retailers of cotton by-products. Certified African cotton is bought at premium prices, part of which is ploughed back to cotton farmers' gate prices for seed cotton, thereby leading to sustainability in production and to increased yields at farm levels. Among other initiatives in the CHA programme is the plan to run the 'Cotton Seed Improvement Program' aimed at improving African cotton planting seed quality. The cotton seed quality in Africa is perceived to be poor and identified as one of the main causes of low cotton yields. The first phase of the program will comprise a study on the state of cotton seeds in four African cotton producing countries: Zambia, Tanzania, Ivory Coast and Burkina Faso (Anon. 2018c). The CHA in collaboration with Cotton Development Organisation (CDO) of Uganda organised the 2nd Pan-African Cotton conference 1-2 November 2018 in Kampala Uganda. The conference attracted a total of 168 delegates drawn from 20 different countries. The objective of the conference was to 'provide a platform for actors in the African cotton sector to network, share sector information and experience with sustainable cotton production'. The theme of the conference was 'Standard and certification in relation to sustainable cotton production in Africa'. The Conference formed a platform for technology transfer. The proceedings of the conference are available on; 'www.cotton-house-africa.org'.

A study was sponsored by the European Union under the auspices of Africa-Caribbean Pacific (ACP) Cotton, on 'Diagnosis and recommendations for the elaboration of a

proposal for revamping strategy of Africa cotton research'. Two reports were produced:

- Seiny B.L and Bachelier B. (2017a). Final Report 'Diagnosis and recommendations for the Elaboration of a proposal for a Revamping Strategy of African Cotton Research'. ACP COTTON, January 2017.
- Seiny B.L and Bachelier B. (2017b). Final Report 'Proposal of a detailed strategy for revamping African Cotton Research at the Technical level', ACP COTTON June 2017.

The reports focused on four strategic objectives that envision:

- Reinforcement of research capabilities on human/scientific capacities, finance and on tools' capacities.
- The adoption of research themes and tools for sustainable production.
- The need for streamlining of research efficiency in the cotton value chain i.e. stressing relevancy of research to the needs of Africa for achieving the aims of research objectives.
- The integration of African cotton research in the worldwide scientific community so African cotton scientists do not work in isolation or 'scientific cocoons'.

Enabling Policies to Boost Yields

Further in addition to the above proposals, suggestions and recommendations, there is need to have in place effective mechanisms for supporting sustainable use of the suggested technologies, human skills and scientific capacity for increasing and sustaining cotton yields in Africa. The required mechanisms include formulating policies, legal frameworks and regulations in place for supporting various activities such as increasing public and private sector funding of Research for development of the production technologies including step-wise multiplication of quality planting seeds and enabling germplasm exchanges between various research programmes, but, in conformity with required Intellectual Property Rights (IPRs).

During the 77th Plenary Meeting of ICAC in Abidjan Ivory Coast in December 2018 the Committee stressed the imminent need for 'Inter-Governmental Policies on Seed-Exchange' (ICAC 2018a). It was emphasised that the exchange of seeds (germplasm) between countries would facilitate progress in cotton production. The narrow genetic base available for cotton improvement in cotton producing countries (including Africa), and the ever-changing market demands for specific fibre qualities, along with the need to improve yields made seed exchange important across countries.

Clearly, access to new germplasm holds the key to genetic improvement, enhancement of genetic diversity, and expanding genetic variability for useful traits. The Speakers (ICAC, 2018a) recommended that Governments develop a roadmap for creating a global platform that operates as a smooth and trustworthy channel of seed exchanges amongst countries across borders. The ICAC Member Governments were also urged to create an International Cotton Research Institute under the CGIAR system, which could act as a research and educational institute and a 'Global Repository' of germplasm sources that could be freely shared.

The CGIAR System is currently comprised of 15 Global Agricultural Research Centers, which are independent and non-profit making, conducting innovative research. These include; Africa Rice Center (AfricaRice), Biodiversity International, Center for International Forestry Research (CIFOR), International Center for Agricultural Research in Dry Areas (ICARDA), International Center for Tropical Agriculture (CIAT), International Crops Research Institute for Semi-Arid Tropics (ICRISAT), International Food Policy Research Institute (IFPRI), International Institute of Tropical Agriculture (IITA), International Livestock Research Institute (ILRI), International Maize and Wheat Improvement Center (CIMMYT), International Potato Center (CIP), International Rice Research Institute (IRRI), International Water Management Institute (IWMI), World Agroforestry Research Institute (ICRAF) and WorldFish; (www.cgiar.org/research/research-center).

- The policy frameworks need to formulate structures and contents of the research programmes in tandem with the requirements or and preferences of all operators along the cotton value chains and comprehensive technology transfer systems from research to the cotton farmers including requirements

for extension services and training of farmers as described and recommended by Sabune and Serunjogi (2017) (Figure 11).

- There is a need to Streamline marketing, under commensurate and stable prices for seed cotton, and processing of the increased cotton volumes produced by the Farmers.
- Periodic reviews by the Cotton sector on catalysts required for sustaining the attained high cotton yields. The reviews should assess, *inter alia*; the ease with which farmers continue accessing standard and true to label, or type, production inputs. This is to safe-guard farmers against infiltration into the cotton production systems of 'fake' and adulterated or sub-standard inputs, a factor which has been identified as one of the causes of low cotton yields in Africa.
- Inclusion of the cotton sector in the 'National Strategic Commodities', under the periodic 'National Strategic Plans', as is the case in Uganda (Anon., 2016).

Recommendations

The above inputs on the required changes for improvement of cotton yields in Africa have been based on literature search of records on what has transpired in Africa at the continent level and on real life observations in the cotton Industry in Uganda. Some information has come from tested or piloted new approaches at public research levels and from private sector initiatives that are yet to be passed to farmers. As a way forward for increasing cotton yields in Africa, the following strategies and activities are recommended;

- Direct more support towards conclusion of ongoing diagnostic and piloting initiatives aimed at increasing cotton yields and find means of implementing the recommendations arising thereof at farm production levels.
- Conduct inventory surveys on all available production technologies and new innovations in the 27 African cotton producing countries. Through literature search and analyses, assess comparative effectiveness of the current and neo-technologies on station and on-farm in countries where they are being used or tested. Ascertain their suitability, through adaptive trials in the 'new' countries, so as to recommend the viable ones for use in other or new African cotton producing countries at farm levels.
- There is a need to identify all available global technologies that can be validated in Africa's cotton research programmes for ease of adoption or domesticating



Figure 11. Technology Transfer: Farmers' Training in a Cotton Demonstration Plot in Uganda.

the suitable ones rather than starting from scratch the exploration for new technology development, a situation which translates into unnecessary and expensive 're-invention of the wheel'. Such approaches should, however, be in conformity with requirements of the 'Intellectual Property Rights' (IPR) in recognition of the inputs of the 'originators/inventors' of the new technology.

- Assess, recommend and support the required collaborations between the activities and approaches of Institutions which are forging towards increasing cotton yields and quality in Africa.
- Assess requirements for the sustainability of those new approved and recommended initiatives and approaches along the entire African cotton value chains.
- Develop technology transfer strategies especially for the new technologies and implement them across the African cotton producing countries.
- Creation of a Cotton CGIAR Research Center as recommended by the ICAC 77th Plenary Meeting (ICAC 2018a).

Conclusions

For achieving the above objectives toward increasing cotton yields in Africa, there is need for the coordinating bodies — ICAC, CHA, and others — in these initiatives, to forge means of having the member governments and the private sectors working in tandem. This is to ensure conformity for amicable legal environments and financial aspects to support the new developments in the respective countries towards sustainable increases in yields of high fibre quality cottons in Africa. One way towards this goal is to create a cotton CGIAR Research Center. The new CGIAR will play roles pertinent to cotton but similar to the already existing 15 CGIARs on other commodities which are in place alongside cotton in the various farming systems and in National economies.

References

- Anon. 2019. The 'Uganda New Vision Daily Newspaper', February 6th, 2019. Vol.034 No.027 pp6. 'GMO Bill: Scientists Want Strict Liability Clause Dropped'.
- Anon. 2018a. The 'Uganda Observer Weekly Newspaper', November 29th, 2018. 'Parliament Passes GMO Bill'.
- Anon. 2018b. www.iwm.org.uk. The British Empire Cotton-Growing Corporation's Research Station at Namulonge, Uganda (CIRCA 1950S).
- Anon. 2018c. Cotton Seed Improvement Program. A Flier by: Cotton Expert House Africa (CHA) and CIRAD.
- Anon. 2016. Cotton: In 'Agriculture Sector Strategic Plan 2015/16-2019/20'. The Republic of Uganda. Ministry of Agriculture, Animal Industry and Fisheries (MAAIF).
- Bachelier B. 2018. Cotton Research in Africa: a Diagnostic Study and Proposal for a relaunch. Cotton Outlook. Abidjan 2018. ICAC 77th Plenary Meeting pp 20 – 25.
- CDO Annual Report 2017-18 Season
- CDO website: www.cdouga.org
- CHA 2018: Cotton Expert House Africa, <http://www.cotton-house-Africa.org/vision>.
- CIRAD 2018. Agricultural Research for Development 2018. Cotton seed Improvement Programme in sub-Saharan Africa.
- Desouza B. 2018. Conservation Agriculture for Sustainable Cotton Production in Africa. In. The ICAC Recorder, December 2018 Volume XXXVI, No. 4. Special Issue (Volume 2). Pp 23 – 28.
- Dong, H and Fok, M. 2018. Light and Simplified Cultivation (LSC) Techniques and Their Relevancy for Africa. In. ICAC Recorder, December 2018. Volume XXXVI, No.4. Special Issue (Volume 2). Pp. 15 – 21
- Elobu P, Orwanga J.F, Ocan J. R, and Opolot G.W. 1995. Recovery of cotton (*Gossypium hirsutum*) from intercropping Suppression by Beans (*Phaseolus vulgaris*). In Proceedings of the World Cotton Conference 1: Challenging the Future: pp. 206 – 209. (Ed.) Constable G.A. and Forrester, N.W.
- Elobu P, Kabanyoro R, Orwangga J.R, Ocan J.R, and Mukalazi W. 1997. Response of Cotton to 'Pix' Application in Uganda. African Crop Science Conference 3, Proceedings; pp 657 – 663. African Crop Science Society.
- Elobu P, Ocan J.R, Olinga J, and Ogabe P, 2016. Use of *Tithonia diversifolia* to improve cotton productivity under marginal soils in Uganda: In Proceedings of the World Cotton Research Conference VI. Goiana Brazil, May 2016.
- Elobu P, Ocan J.R, Ogabe P, and Olinga J. 2017. A Technology Dissemination Flier, NARO-NaSARRI. *Tithonia diversifolia*- An Organic Means to improve Cotton production Potential in Uganda.
- Elobu P, Ocan J.R, Ogabe P, and Olinga J. 2018. A Final Report on Testing Vitazyme on Cotton in Uganda during 2015 – 2018. NARO Annual Report for 2018. In Press.
- Farid Uddin, Fakhre Alam Ibne Tabib, Kamrul Islam, Washington Mubvekeri, M. Sabesh and Usha Rani Joshua. 2018. Novel Ideas to Enhance Cotton Production and Value of By-products in Africa. (A compilation of six concept notes on novel ideas proposed by six authors). In: ICAC Recorder; September 2018 Volume XXXVI, No.3; Special Issue (Volume 1), pp 13 – 17.
- Gayi D, Ocen D, Lubadde G and Serunjogi L.K, 2016. Efficacy of Bio and synthetic Pesticides against the American Bollworm and their natural Enemies on cotton. Uganda Journal of Agricultural Sciences: 17 (1) pp 55 – 69.
- Gayi D, Orawu M, Biruma M, Ocen D, Ejiet E.I, Echaku S, and Kyeeyune U, 2017. Management of Bollworms in Cotton. A brochure published by NaSARRI and NARO.
- ICAC 2018a. www.icac.org/Events, Plenary Meetings. The Final Statement of the 77th Plenary Meeting, Abidjan-Ivory Coast-December 2018.
- ICAC 2018b. The 'ICAC Recorder', December 2018 Volume XXXVI, No.4

- ICAC 2018c. The 'ICAC Recorder', September 2018 Volume XXXVI, No.3.
- ICAC 2013. [www.icac.org/Press-Release/2013/PR-42-Standardization of Nomenclature in Cotton Planting Seed](http://www.icac.org/Press-Release/2013/PR-42-Standardization%20of%20Nomenclature%20in%20Cotton%20Planting%20Seed).
- ISAAA. 2018. Crop Biotech Update, August 2018. Nigeria registers Biotech Cotton Varieties for Access to Farmers. International Services for the Acquisition of Agri-biotech Applications (ISAAA).
- Jiwei Z, Dhammi A, Roe R.M, Stewart D, and Roswell G.A. 2016. Novel mechanical Pesticides for Tobacco Thrips, *Frankliniella fusca*, Control in Cotton. Beltwide Cotton Conference, New Orleans, LA January 5-7, 2016. pp 704 – 712.
- Kranthi K.R. 2018a. Biotech Cotton-Relevance for Africa. In: ICAC Recorder; December 2018 Volume XXXVI, No. 4; Special Issue (Volume 2). Pp 29 – 34.
- Kranthi K.R. 2018b. A Change in Plant Architecture Can Break Yield Barriers in Africa. In: ICAC Recorder; September 2018 Volume XXXVI, No.3; Special Issue (Volume 1), pp 13 – 17.
- Kranthi K.R. 2018c. Uganda, Can Cotton Yields be Doubled? In: 'Proceedings of the; United Nations Conference on Trade and Development (UNCTAD), National Workshop held in Kampala Uganda 14 – 16 March, 2018'. UNCTAD Project on 'Promoting Cotton By-products in Eastern and Southern Africa i.e. Tanzania, Uganda, Zambia and Zimbabwe'.
- Ogwal S, Epieru G, Barwogeza M, and Acom, V. 2003. Effect of Inter-cropping Systems on establishment and biological Control Efficacy of the *Lepisiota Spp.* Predator Ant on Major Insect Pests. Uganda Journal of Agricultural Sciences 8, pp. 67 - 74
- Orawu M, Amoding G, Serunjogi L.K, Ogwang G and Ogwang C.O. 2017. Yield Stability of Cotton Genotypes at Three Diverse Agro-Ecologies of Uganda. Journal of Plant Breeding and Genetics 05 (03)2017, pp 101-114.
- Sabesh, M. 2018. Hope and Scope for Enhancing Cotton Production in Africa. In: ICAC Recorder; September 2018 Volume XXXVI, No.3; Special Issue (Volume 1), pp 18 – 24.
- Sabune, Jolly K. and Serunjogi L.K. 2017. Technology Transfer to Enhance Cotton Yield and Fiber Quality in Uganda. ICAC Recorder VOL XXXV No 4, December 2017, pp 4 – 13. International Cotton Advisory Committee.
- Seiny B.L and Bachelier B. 2017 (a). Final Report 'Proposal of a detailed strategy for revamping African Cotton Research at the Technical level', ACP COTTON June 2017.
- Seiny B.L and Bachelier B. 2017 (b). Final Report 'Diagnosis and recommendations for the Elaboration of a proposal for a Revamping Strategy of African Cotton Research'. ACP COTTON, January 2017.
- Sekamatte, M.B, Serunjogi, L.K, El-Heneidy, A.K. 2003. Gaining Confidence in Farmer Participatory Pest Management in Uganda. NARO's Experience in Improving Uptake of Crop Protection Technologies for Cotton. In: Proceedings of the World Cotton Conference-3. Cotton Production for the New Millennium pp. 697 – 974. (Ed.) Swanepoel, A.
- Serunjogi L.K, Sabune, J.K. and Akello, B. 2014. Balancing input Use: Mechanisms and Impact on Quality of Cotton. In: Proceedings of the 6th Session/Technical Seminar of the 73rd Plenary Meeting of ICAC, Thessaloniki Greece (www.icac.org/Meetings).
- Serunjogi L.K, Martin S.K, and Bauer W.D. 2002. Effects of Genotype x *Bradyrhizobium* Inoculation x Fertilizer interactions on Genetic Gain While Selecting in Soya bean. Uganda Journal of Agricultural sciences 7. Pp 1-6.
- Serunjogi L.K, P. Elobu, G. Epieru, V.A.O Okoth, M.B Sekamatte, J.P Takan and J.O.E Oryokot. 2001. Cotton (*Gossypium Sp*) in Agriculture in Uganda Vol II (Ed) J.K. Mukiibi, Fountain Publishers/CTA/NARO pp322-375.
- Syltie P.W 1985. Effect of Very Small Amounts of Highly Active Biological Substances on Plant growth. Bio. Agric. Hort.2: pp 245 – 269.
- USDA November2018: www.indexmundi.com-Agriculture-cotton-Yield.



The challenging task of evaluating impact: COMPACI's evaluation framework and summary of results

Daniela Jann and Tobias Bidlingmaier,
DEG-Deutsche Investitions- und Entwicklungsgesellschaft mbH
Kämmergasse 22, 50676 Cologne, Germany

This article was published previously in CmiA and COMPACI News 14th Edition, 12/17

COMPACI's overall objective was to improve the livelihoods of smallholder cotton farmers and their families. Training in better and sustainable farming techniques (for example, good agricultural practices, conservation agricultural techniques, integrated pest management, safe pesticide use and handling) as well as better farm management (farming as a business), access to quality inputs and input pre-finance, empowerment of female farmers, and access to markets for sustainable cotton were meant to increase farmers' cotton as well as food crop production, and consequently income (see Figure 1).

- In addition to these measures, COMPACI's impact was externally evaluated by the National Opinion Research Center (NORC). NORC conducted a quantitative impact evaluation in the six original COMPACI I countries (Benin, Burkina Faso, Côte d'Ivoire, Malawi, Zambia and Mozambique) and supported findings with qualitative Focus Group Discussions.

The following paragraphs highlight the main findings from the various studies.¹

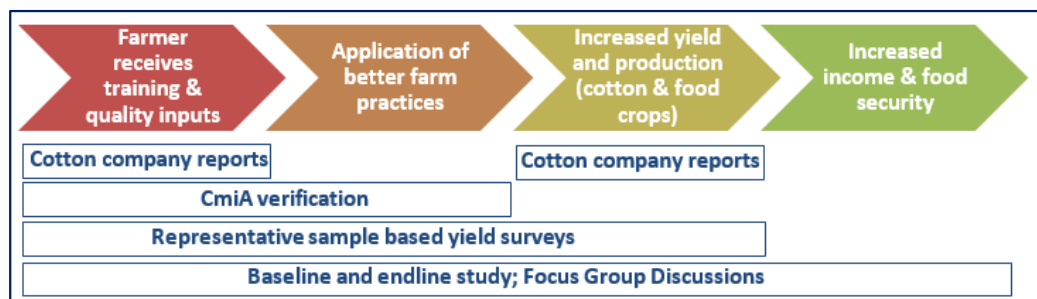


Figure 1: COMPACI's theory of change and evaluation framework

Monitoring and measuring outputs, outcomes and impacts were an important and integral part of COMPACI. This task was performed on different levels by different actors:

- The number of farmers trained in different techniques, the provision of quality inputs, cotton yields, and total cotton production were monitored bi-annually by the cotton companies (cotton company reports);
- External CmiA verification conducted every two years verified cotton companies' self-reported figures and assessed the application of agricultural practices by farmers;
- Since 2013, surveys have been conducted, during which cotton yield has been estimated by counting cotton bolls on the fields of a representative sample of cotton farmers;

Farmer training

By 2016, the final year of project implementation of COMPACI II, many more farmers had been reached by COMPACI than originally intended: COMPACI II was implemented by a total of 22 cotton companies in 12 countries. These companies trained almost one

million smallholder farmers in sustainable agricultural techniques in sub-Saharan Africa, reaching out to 25% to 30% of all cotton farmers in sub-Saharan Africa. Many of these farmers attended regular training sessions, meaning COMPACI cotton companies organised more than 60,000 training sessions annually.

Additionally, 240,500 farmers learned intensively in one-week Farmer Business School (FBS) trainings which support farmers to lead their farm as a business. A third of trained FBS farmers were female.

Application of better farming techniques

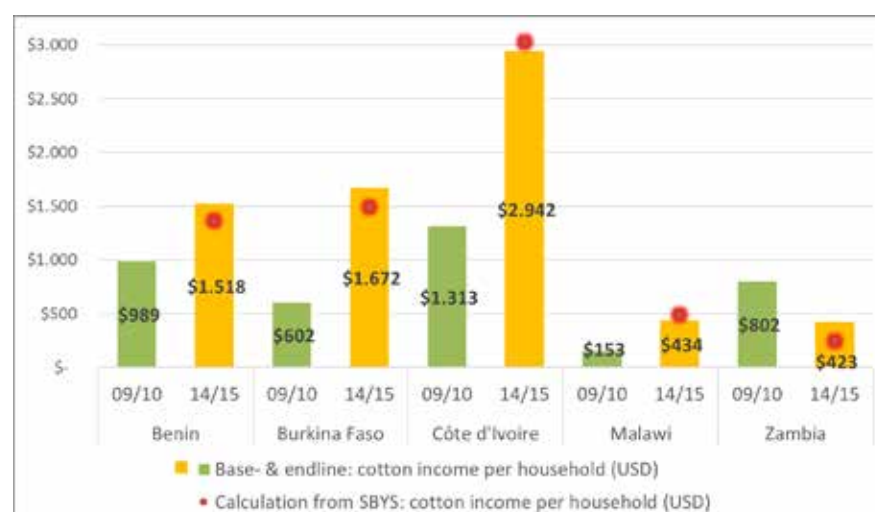
The application of better farming techniques increased over the course of COMPACI. Survey results show that, overall, 80% of COMPACI farmers apply good agricultural practices and 60% practice two or more soil fertility

1) All prices in the following summary are inflation-adjusted and converted to USD using the 2015 PPP conversion factor for private consumption of the World Bank.

techniques to maintain or improve the fertility of soils and prevent erosion at the end of COMPACI. More than 80% of trained FBS farmers apply their knowledge to their farm and started, for example, keeping record of their farming activities. The proper use and handling of chemicals also improved greatly over the course of COMPACI, but still has room for improvement, as 60% to 75% of farmers store and dispose of chemicals correctly and wear protective clothing when spraying pesticides.

Cotton yield, production and income

Cotton income per COMPACI household increased massively in four out of six countries over the course of implementation (compare to Figure 3). On average, COMPACI farmers increased their cotton income by more than 98% and are therefore much better off at the end of the project. Figure 3 also shows the huge gap between West African (WA) cotton farmers and cotton farmers from Eastern and Southern Africa (ESA): While WA cotton farmers have an average cotton income between \$1,500 (Benin) and \$2,942 (Côte d'Ivoire), ESA cotton farmers' cotton income ranges from only \$204 (Mozambique) to \$434 (Malawi).



Source: NORC endline reports; NORC sample based yield survey reports 2014/15

Figure 3: Cotton income per COMPACI farm household (USD)

Cotton income is, however, not only determined by COMPACI participation, but heavily affected by external factors such as weather and prices. The introduction of *comparison groups*, experiencing the same external effects as COMPACI farmers but not receiving COMPACI support, was supposed to make it possible to single out the effect of COMPACI in NORC's impact survey.

However, it was not possible to preserve this survey setup in all six countries. Over the course of the program implementation, many *comparison* farmers in Zambia,

Mozambique and Côte d'Ivoire became COMPACI farmers. In Benin, Malawi and Burkina Faso *comparison* farmers did not become part of COMPACI, but received training by other actors, such as NGOs, government extension or others. It was thus in many cases difficult to properly determine the effect of COMPACI in the NORC surveys.

Nevertheless, it is still interesting to look at different components that influence cotton income (such as cotton yield, area, production, costs of production and farm gate prices) and how they developed between the baseline survey (2010) and the endline survey (2015).

Cotton yield (kg/ha) of COMPACI farmers increased in Malawi and Burkina Faso and stayed more or less constant in the other countries, between baseline and endline. The yield increase in Burkina Faso, however, is mainly caused by farmers switching from conventional cotton to GM cotton; statistical analysis cannot determine a significant effect of COMPACI on yields. In Malawi, cotton yield increased much more for COMPACI farmers (50%) than for *comparison* farmers (14%), but the positive relation between COMPACI and cotton yields is not statistically significant. In Benin, COMPACI farmers maintained their

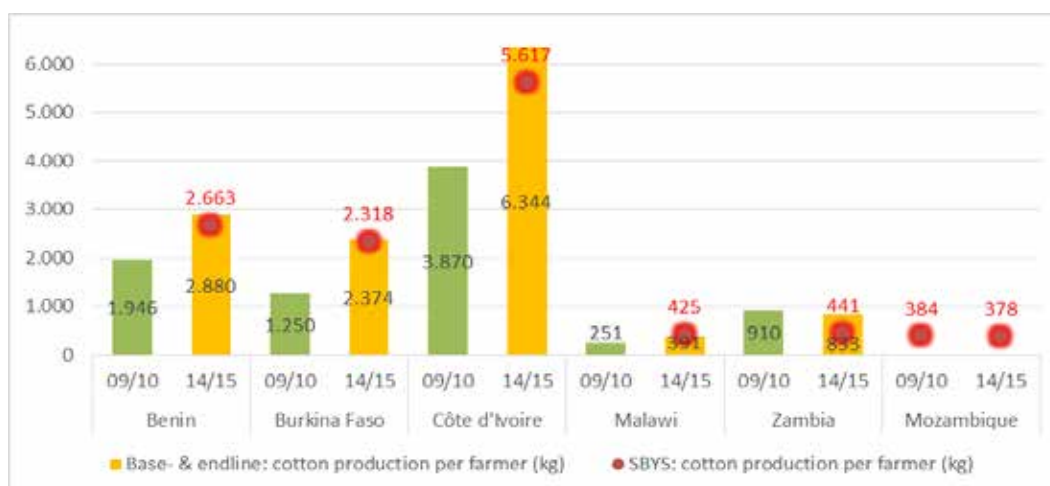
cotton yields, while, at the same time, *comparison* farmers' cotton yield *decreased* by 33%. Statistical analysis therefore reveals a significant positive effect of COMPACI on yields in Benin.

Cotton area per COMPACI household more than doubled in Benin and Côte d'Ivoire, while it increased by more than 30% in Burkina Faso and Malawi. In Zambia and Mozambique, cotton area remained constant. Food crop production was, however, not jeopardized in any country. The percentage of cotton area to total farm area only increased slightly and ranges between 30% and 39%. Therefore, crops other than cotton still constitute the majority of production in all countries.

Cotton production per COMPACI household increased in all countries but Zambia and Mozambique, mainly due to increased cotton area. Figure 2 shows that COMPACI households in WA countries produce much more cotton than farmers in ESA.

Costs of cotton production per hectare for COMPACI farmers (e.g. costs of cotton seeds, pesticides, herbicides, fertilizers and hired labour for cotton production) increased by up to 45% in all countries but Malawi and Mozambique. Absolute costs at endline are much higher in WA countries (\$430 to \$520) than costs in ESA countries

2) The following findings thereby only refer to the six original COMPACI countries and cannot be extrapolated to the other six COMPACI II countries.



Source: NORC endline reports; NORC sample-based yield survey reports 2014/15

Figure 2: Average cotton production per COMPACI household (kg)

(\$31 to \$100), because most farmers in ESA countries do not fertilise their cotton.

Farm gate price per kilogram of seed cotton increased in all countries but Zambia and Mozambique. While farm gate prices in WA countries increase slowly but (more or less) linearly between 2009 and 2015, farm gate prices in ESA countries mirror the world market price for cotton and thus fluctuate heavily from year to year.

Country summary findings

Benin

COMPACI farmers in Benin were able to maintain their average cotton yield per hectare in declining conditions (in which comparison farmers had declining cotton yields). By increasing their cotton area by 27%, COMPACI farmers were thus able to raise their cotton income from \$989 to \$1,518. Comparison farmers had a similar cotton income at endline but had to increase their cotton area by 150% to offset their declining yields. Regression analysis hence shows that COMPACI had a positive impact on cotton income (when controlled for area). According to statistical estimates, the effect of COMPACI exposure would be an average cotton income increase of almost \$150 per cotton hectare when inflation-adjusted.

Burkina Faso

In Burkina Faso, cotton income per ha increased more for COMPACI farmers than for comparison farmers, but income per household increased more for comparison farmers than COMPACI farmers. This is because comparison farmers increased their cotton area to 2.9 hectares while COMPACI farmers only grew 1.9 hectares of cotton on average at endline. Overall, one can conclude that COMPACI farmers' average cotton income mainly increased due to a combination of farmers switching to GM cotton, increasing cotton area and increased farm gate prices. Regression

analysis cannot detect any effect of COMPACI on cotton income when it controls for farmers switching to GM cotton.

Malawi

Cotton income per farm household increased for both, COMPACI and comparison farmers, but much more for COMPACI farmers. This difference can largely be explained by lower cotton yields of comparison farmers and higher costs of cotton production for comparison farmers. Statistical analysis shows a positive significant relationship between COMPACI and cotton income increase.

Côte d'Ivoire

Côte d'Ivoire has no comparison group and only 41 farmers were interviewed at base- and endline, which is why results must be treated with care. This small group of farmers had an impressive increase of cotton income, mainly due to a combination of increased cotton area, higher farm gate prices and constant cotton yield. Statistical analysis could not detect a correlation between COMPACI training attendance and cotton income.

Zambia

Comparison group farmers became COMPACI farmers over the course of COMPACI in Zambia. For the 118 farmers interviewed at baseline and endline, cotton income decreased by 47% on average. The main reasons for this decrease are the following: falling farm gate prices and increasing input prices at constant cotton yield and cotton area. Statistical analysis indicates a positive but weak relationship between COMPACI training attendance and cotton income.

Mozambique

Different farmers were interviewed at baseline and endline and no statistical analysis on the effect of COMPACI on cotton income could thus be conducted.



Promoting cotton by-products in Eastern and Southern Africa: Lessons from a United Nations technical assistance project

Kris Terauds, Economic Affairs Officer, UNCTAD, kris.terauds@un.org
(standard disclaimer – author writes in his personal capacity)

Introduction

In many African countries, cotton production has languished in the two decades since liberalisation (Tschirley et al, 2009). Many factors contributed to this decline, perhaps none more fundamental than farmers deciding that other crops are more profitable to grow than cotton (Baffes, 2009). In many African countries, limited value addition constrains the prices paid to farmers: Nearly all lint is exported, leaving cottonseed oil expression as the only additional source of value-added income that can be factored into producer prices. Strategies to revive cotton production must therefore increase value addition, to expand the income pool from which to remunerate farmers.

In its 2009 Regional Cotton-to-Clothing Strategy¹, the Common Market for Eastern and Southern Africa (COMESA) Secretariat acknowledged the need to improve incentives for farmers. Among its recommendations, it identified the development of cotton by-products as a source of new income opportunities for the sector.

With this rationale, the United Nations Conference on Trade and Development (UNCTAD) is implementing a technical assistance project on 'Promoting cotton by-products in Eastern and Southern Africa' in Tanzania, Uganda, Zambia and Zimbabwe. The project is funded by the United Nations Development Account and its calendar of activities runs from 2016 until the end of 2019.

The overall objective is to build countries' capacity to evaluate and pursue new opportunities to add value to cotton by-products, derived from, for example: cotton stalks, cottonseed meal or the short-staple fibres disposed of by ginner and spinners. This is meant to contribute to increased income opportunities for farmers and entrepreneurs, especially in rural areas, and to a more resilient cotton sector overall.

Surveys Underline Raw Material Supply Challenge

Project activities began with national surveys, which gathered baseline information and stakeholders' views on

challenges facing the development of cotton by-products. Findings in all four countries identified that a limited supply of raw material was the root challenge facing cotton by-products businesses². The total quantities of some raw materials, such as linters or hulls, preclude them entirely from commercial-scale ventures. Even oil expressers — the most established value-added industry in the chain — find it difficult to turn a profit with the available quantity of raw material. This mirrors the challenge facing the textile and apparel industries, which have largely collapsed in the project countries. Although unsurprising, this finding underlines the need to address cotton production as part of any value-addition strategy, chiefly by reviving incentives for African farmers to grow cotton.

Secondary challenges identified by survey respondents included a lack of awareness about commercial applications for cotton stalks and other residues along the value chain. In particular, few farmers responding to the surveys were aware of the potential applications for their stalks. Survey respondents also highlighted trade policy as a challenge for some local products, subject to VAT, that struggle to compete with duty-free imports of, for example, edible oil and second-hand clothes.

Countries Aim to Utilise Cotton Stalks

Following the surveys, UNCTAD organized national capacity-building workshops, each gathering 50 to 80 stakeholders from the local cotton sector. The workshops led stakeholders through an evaluation of by-product opportunities, informed by presentations by the survey authors and experts from, for example, the Central Institute for Research on Cotton Technology (CIRCOT) in India, the German development agency GIZ, and the International Cotton Advisory Committee (ICAC). Stakeholders then agreed on a National Action Plan, comprised of 2 to 4 priority cotton by-products for development and supporting policy recommendations. See Table 1 for the by-products selected by each country.

As shown in Table 1, biomass briquettes and pellets, made from cotton stalks, were the most attractive cotton

1) https://unctad.org/en/PublicationsLibrary/suc2017_Regional_COMESA_Strategy.pdf

2) Survey reports and other documentation are available on the project site: <https://unctad.org/en/Pages/SUC/Commodities/SUC-Project-1617K.aspx>.

Table 1 - Priority cotton by-products in National Action Plans

Raw material	End product	Tanzania	Uganda	Zambia	Zimbabwe
Cottonseed cake	Gossypol-free cake	Yes	Yes		Yes
Short-staple cotton	Absorbent cotton wool	Yes	Yes	Yes	
Stalks / hulls	Mushrooms		Yes		
Stalks	Briquettes and pellets	Yes	Yes	Yes	Yes



Figure 1. Demonstration of absorbent cotton wool plant, Surgical Cotton Wool Industries, MIDC Industrial Park, Butibori, Nagpur district



Figure 2. Demonstration of microbial gossypol removal process for cottonseed cake at the ICAR-CIRCOT Ginning Training Centre, Nagpur

by-products selected in all four countries. Several factors contributed to their appeal. They offered the greatest income potential for farmers, who can sell their stalks to processors, or even establish small-scale pelleting operations. Unlike most of the by-products discussed, stalks are relatively abundant and there is no competition for their supply. The value proposition is also

compelling: They are clean fuel substitutes for firewood, charcoal, coal, liquid petroleum gas (LPG) or furnace oil.

The clean fuel advantages of biomass briquettes and pellets dominated discussions to an unexpected degree. In general, UNCTAD had framed the arguments for cotton by-products around their potential economic advantages and, indeed, increased incomes for farmers resonated. But stakeholders in all four countries quickly seized on the potential for biomass briquettes and pellets to replace more polluting fuels. Farmers saw they could replace the smoke-related health hazards of firewood in their homes. Businesses recognized the value of replacing the dust and ash associated with using charcoal or coal in their boilers. Policy makers gravitated to the potential for reducing trade deficits for imported fossil fuels. Most emphatically, stakeholders in all four countries saw biomass briquettes and pellets as a substitute for rampant deforestation, driven by growing populations over-reliant on firewood and charcoal.

Biomass Fuels Could be Competitive in Africa

UNCTAD adapted the remaining project activities to the by-products contained in the four countries' National Action Plans. We provided advisory services to advance the commercial initiatives and policy recommendations. We also delivered practical tools, in the form of investment profiles for the selected cotton by-product processing businesses. For this, we worked in partnership with the national investment promotion agencies, which will become custodians of the profiles.



Figure 3. Chipping of cotton stalks in the field, near Katol, Nagpur District

As part of the investment profiles, our consultants crafted more detailed value propositions to differentiate the profiled product from its substitutes. In the case of biomass briquettes and pellets, examples from around the world underlined that these fuels should, at a minimum, sell at a small discount to charcoal and coal and at a larger one to petroleum-based fuels, such as LPG and furnace oil.

Indeed, the USDA's Cotton Production and Processing Research Unit, which researches commercial applications for cotton by-products, confirmed that they had explored using cotton stalks for biomass fuels, but their production costs made them unlikely to compete with the relatively low prices for fossil fuels in the USA³. The price comparison was more favourable for biomass fuels in the four African project countries, where most fossil fuels are imported and relatively expensive.

Gathering Inspiration From a Study Visit to Nagpur, India

Information and expert advice only go so far; seeing technologies and businesses in operation is necessary to build entrepreneurial inspiration. UNCTAD therefore organized a study visit to Nagpur, India, where several cotton by-products have reached commercial viability over the last decade. Organised by CIRCOT, the institution responsible for research, development and commercialisation of cotton-processing technologies, the study visit aimed to demonstrate to African participants the technologies and business models that have thrived in India, as well as connect them with relevant machine fabricators. CIRCOT organised an excellent programme, including lectures by its scientists, site visits, and a forum with approximately 50

businesses active in the sector.

The cotton stalk supply chain in India was instructive for the African context. As CIRCOT expanded its research on cotton by-products in the 1990s, under then-Director Dr. A.J. Shaikh, it targeted particle boards as an application for cotton stalks (Pandey and Shaikh, 1987). Stalk-based particle boards were subsequently promoted by researchers in Africa.⁴ Nevertheless, despite years of development in India, cotton stalks proved not to be a competitive raw material for particle boards, being less abundant and more expensive than, for example, bagasse straw.⁵ CIRCOT has since focused on biomass briquetting and pelleting for cotton stalks, overseeing the growth of a budding industry over the last 5 to 10 years.

In the businesses they visited in Nagpur, several project participants saw examples that convinced them to invest in



Figure 4. Biomass briquetting plant, Aarohi Bio Coals, Karanja, Wardha District

3) Source: author's discussions with USDA experts.

4) See, for example: Cotton Development Trust, 2008. Project Proposal: Economic Utilization of Cotton By-Products for Zambian Smallholders: Cotton Stalk-Based Chip in the Manufacture of Particle Board. Available at: https://www.icac.org/delegates/sc_notices/sc_meeting_500/500at3.pdf.

5) Source: author's discussions with CIRCOT experts.



Figure 5. Briquette-fired boiler, Pix Transmission, MIDC Industrial Park, Hingna, Nagpur

similar ventures in their countries. For example, one Indian entrepreneur had invested approximately US\$200,000 for a small-scale briquetting plant with a single machine and a capacity of 7,500 metric tonnes (MT) per year. Demand for his briquettes grew faster than anticipated, meaning he was ahead of his original five-year investment payback schedule and intended to invest in a second briquetting machine. He stressed that establishing a cost-effective raw material supply chain — of cotton stalks and other agro-residues — was the make-or-break challenge for his business. Indeed, his plant was operating at approximately 5,000 MT/year, due to competition for raw material from other buyers.

Table 2 shows an estimated profit breakdown for a briquetting plant in India, with a capacity of 20 MT/day.

Table 2 - Estimated profit breakdown for 20 MT/day briquetting plant, India

Supply chain node	Cost item	US\$ per MT
Harvesting	Uprooting of stalks	7.1
	Sun drying (labour)	0.71
Chipping and collection	Material cost	5
	Chipping	2.9
Transportation	Transportation within 30-40km	9.3
	Unloading at factory site	0.71
	Subtotal – raw material	25.72
	Weight loss (10%)	2.57
Pre-processing	Hammer milling	2.5
Processing	Briquetting	9.3
	Total production cost	40.09
	Sale price (range)	45.70 - 51.40
	Profit (range)	5.61 – 11.31

Source: CIRCOT

It emphasises the importance of controlling raw material costs, in particular transportation.

Other elements of the briquetting plant's business plan were less complex. The machinery was relatively simple to operate and preventative maintenance kept stoppages and repairs to a minimum. Marketing was similarly straightforward: Dealers and end users in India recognised the advantages of biomass briquettes and he routinely sold his entire production with minimal marketing cost.

In addition to the business model, adapting the Indian examples to the African context will require several other considerations. Compressing biomass into dense fuels requires considerable force, so briquetting and pelleting machines typically require three-phase power, which is not widely available in rural areas in Africa. Participants on the study visit also remarked about the absence of ventilation systems in the

Indian plants, resulting in uncomfortable and potentially hazardous air quality for workers. Nevertheless, installing ventilation systems would significantly increase the initial investment required for these plants.

More generally, the participants marvelled at the research system that supports agro-industrial development in India. The state-funded Indian Council of Agricultural Research (ICAR) is one of the largest networks of agricultural research institutions in the world and includes the Central Institute for Cotton Research (CICR) and CIRCOT. During the study visit, participants not only learned from lectures and site visits, but they were observing the fruition of approximately 30 years of CIRCOT's work on

researching and commercializing cotton by-products processing technologies, carried out in close collaboration with the private sector. Comparable examples of well-funded research institutions with long-term public-private collaboration are rare, in Africa and elsewhere.

Next Steps

For the remainder of the project, until the end of 2019, UNCTAD will assist the countries in drafting investment plans and project proposals for their selected initiatives. Country representatives will present these initiatives, as well as share lessons from the project, at a wrap-up

workshop in mid-2019, to which UNCTAD will also invite donors and partners. We hope to have one or two concrete projects spring out of this first capacity-building phase.

As well as following up on its current project, UNCTAD has undertaken a joint initiative on cotton by-products with the WTO and ITC. The three 'sister' trade institutions proposed the initiative to respond to Member State requests, coordinate their work and capitalise on their complementary areas of expertise. WTO Members endorsed the joint initiative at the November 2018 Cotton Days proceedings.⁶

Conclusion

Experience from UNCTAD's project on 'Promoting cotton by-products in Eastern and Southern Africa' suggests there is potential to establish profitable processing businesses in Africa for selected cotton by-products, such as absorbent cotton wool and biomass briquettes and pellets. Commercially viable technologies and business models exist in India and elsewhere, representing opportunities for South-South cooperation and examples for African entrepreneurs to adapt in their countries. Generating additional income in the cotton value chain can help increase seed cotton prices paid to farmers and

revive their incentives to grow more cotton.

Acknowledgements

UNCTAD is grateful for the capable coordination provided by the project's country focal points: the Ministry of Industry, Trade and Investment in Tanzania; the Cotton Development Organisation in Uganda; the Ministry of Commerce, Trade and Industry in Zambia; and the Ministry of Industry, Commerce and Enterprise Development in Zimbabwe. Thanks also to our valued partners — the United Nations Economic Commission for Africa (UNECA), COMESA and CIRCOT — and to the motivated stakeholders and associations that have animated the project's activities.

References

- Baffes, J. 2009. The 'Full Potential' of Uganda's Cotton Industry. *Development Policy Review*, 27: 67-85. doi:10.1111/j.1467-7679.2009.00436.x.
- Pandey, S., Shaikh, A. 1987. Utilisation of cotton plant stalk for production of pulp and paper. *Biological Wastes*, 21:1: 63-70. doi: 10.1016/0269-7483(87)90147-9.
- Tschirley, D., Poulton, C., Labaste, P. 2009. *Organization and Performance of Cotton Sectors in Africa*. The World Bank, Washington D.C. ISBN: 9780821377703.

6) https://www.wto.org/english/news_e/news18_e/cott_07dec18_e.htm



Progress of Ethiopian Cotton Producers toward Sustainability

Zerihun Desalegn, Cotton Projects Manager, SOLIDARIDAD,
Addis Ababa, Ethiopia, zerihun.desalegn@solidaridadnetwork.org

Abstract

'Sustainable Cotton Initiative Ethiopia (SCIE)' introduced pilot interventions of sustainable production principles on large and smallholder farms in the regional states of Afar and Tigray. Lessons were drawn during the implementation period to create a success case that can serve as an example for scaling-up similar support models to other cotton-growing regions in Ethiopia. A business case for production of sustainable and profitable cotton was established through the pilot project, resulting in quality produce that ensured market uptake of sustainable cotton. In 2017, at the beginning of the SCIE interventions, the level of compliance of the project farms toward the minimum requirements of the better cotton initiative ranged from 52% to 69%. The next year, compliance level reached 65% to 90%, with a 13% to 23% adoption rate of good agricultural practices. The remaining gap towards certification ranged from 10% to 35%, to be fulfilled depending on the commitment of the project farms and project interventions during 2018 cropping season.

Introduction

The Growth and Transformation Plans (GTP II) and Ethiopia's National Cotton Development Strategy (NCDS 2017) urge for a fivefold increase of lint production. The ambitious development plans incorporate global sustainability standards such as the Better Cotton Initiative (BCI) and Cotton made in Africa (CmiA), which are becoming mainstream production systems (BCI 2013 and CmiA 2014/15) due to the strong commitment of international brands and retailers like HandM, PVH, VF, Adidas, CandA, Nike and Timberland, who are committed to sourcing 100% of their cotton supplies from reliable sustainable sources by 2020 (FAO and ICAC 2015).

SCIE introduced pilot interventions of sustainable production principles on large and smallholder farms in the Ethiopian cities of Afar and Tigray. The pilot projects provided a robust proof-of-concept to create a success case that can serve as an example for scaling up similar support models to other cotton-growing regions in Ethiopia. The pilot interventions demonstrated a business case for producing high-quality cotton products in a sustainable and profitable manner to ensure market uptake of sustainable cotton as per the demands from the national and international markets. This approach is fully aligned

with government ambitions to boost cotton production in a sustainable way and contributing to the competitiveness of the textiles and garments industry. The fact that all the value chain actors are represented in this pilot project creates an opportunity to deliver this ambition to present a unique example of integrated value chains from fibre to fashion.

Currently, the number of 'better cotton initiative' pilot project farms are limited to Afar and Tigray, with rain-fed and irrigated commercial farms operated by 76 lead farmers on 1,166 hectares of better cotton area to produce 1,132 tonnes of sustainable cotton fibre that reaches the targeted supply chain.

The primary aims of the pilot intervention are to transform cotton into a sustainable, mainstream commodity through improvement of farmers' income and livelihoods. Improvement in environment variables and improved working conditions, health and safety.

Methodology

Both CmiA and BCI improvement requirements promote environmentally friendly cotton production systems as well as decent working conditions and realise their financial profitability (FAO and ICAC 2015) through contributions to a vibrant cotton sector by increasing the adoption of good agricultural practices, linking farmers to a secure and growing demand of retail partners for sustainable cotton. That is the path to achieving environmentally, socially and economically sustainable production systems. As per the requirement of Better Cotton Program, a baseline survey and progress of the project activities was evaluated by a team of experts from partner organizations (BCI 2014/2015). For the large-scale project farms, both pre- and post-intervention assessment was done based on the Better Cotton minimum and improvement requirements which included six production principles, 44 production criteria and eight result indicators. The total number of farm-level indicators of sustainability dimensions include environmental (16), social (22) and economic (6) sustainable production systems (FAO and ICAC 2015) and (BCI 2013). For the smallholder farmers under Dansha Aurora Multi-purpose farmers' cooperative union, both pre- and post-intervention self-assessment was done based on the CmiA improvement requirements of 30 farm-level sustainability indicators that included

environmental (10), social (16) and economic (4) sustainable production systems (FAO and ICAC 2015). Based on the assessment and identified gaps in 2016, the subsequent project activities were designed and implemented in 2017.

Sustainability Metrics

Water and Pesticide Usage

The average performance of the project farms showed significant progress in fulfilling the minimum requirements of 'better cotton' depending on their level of commitment. There were significant improvements on environmental variables, reduction of pesticides, improved water use efficiency, reduction in cost of cultivation and improved working conditions/health and safety due to use of bio-intensive practices and IPM compatible pesticides. Water management issues were very limited in Dansha, Tigray, except shortage of rainfall during the growing season (Fig. 1). Progress was made in irrigated project farms of Afar in terms of water scheduling and measurement.

Individual evaluation of the pilot project farms indicated that Dansha smallholder farmers were leading in fulfilling the minimum requirements, as they are the lowest consumers of pesticides due to highest rate of adoption of bio-intensive crop protection and good agricultural practices. The cost of pesticide use was 97% lower and the usage of active ingredient of hazardous pesticides was nil (Figures 2 & 3).

The Hiwot farm is one of the leading rainfed commercial cotton farms in the country, complete with established pivot irrigation technology. To fulfil the minimum requirements, the farm increased the number of rotational crops and started implementing IPM to reduce pesticide and application costs by 39%. The load of active ingredient of hazardous pesticides was also reduced by 50%. Interestingly, the farm workers organised under a labour union had the fewest social issues.

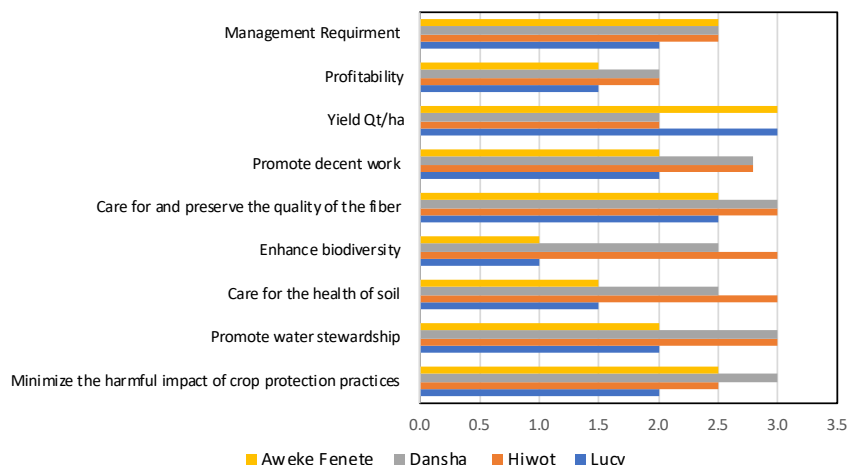


Figure 1. Sustainability performance of project farms

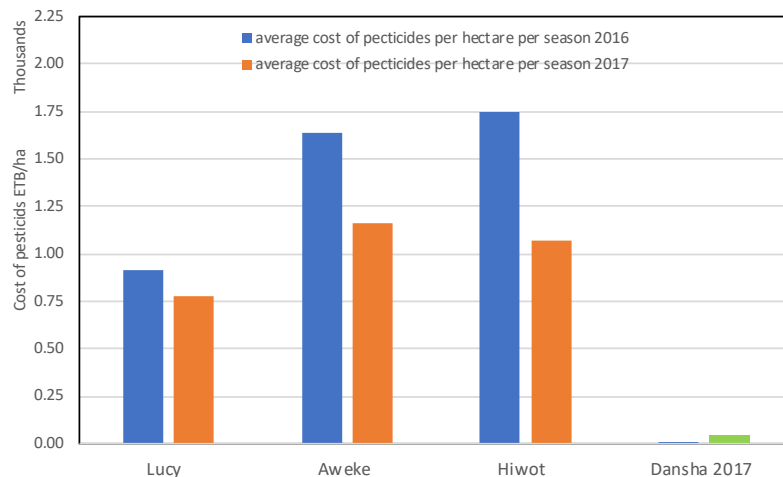


Figure 2. Reduction in pesticide cost

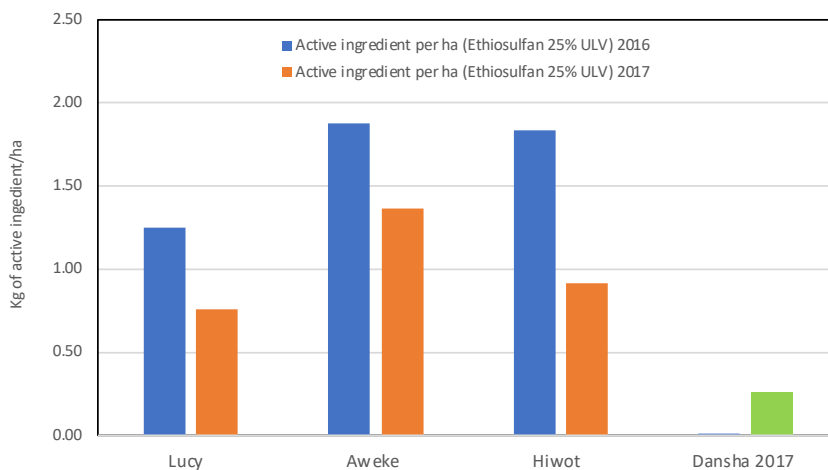


Figure 3. Reduction of insecticide active ingredient (a.i)

The Lucy farm is one of the leading irrigated commercial cotton farms in the Afar region. The farm is known for its high productivity and implementation of IPM, which resulted in a 34% reduction of pesticide application costs and a 5.3% reduction in the use of active ingredient of hazardous pesticides (Figures 2 and 3).

The Aweke Fente farm is one of the most stable commercial cotton farms in the Afar region. The farm joined SCIE after a few supervised training sessions. The farm is known for its productivity and started implementation of IPM, leading to a 25% reduction in pesticide application costs and a 25% reduction in the use of active ingredient of hazardous pesticides (Figures 2 and 3).

Both the Lucy and Aweke Fente farms at Afar are currently striving to solve water-management issues and are committed to improving workers' issues and the livelihood of the Afar community.

Compared to the base year 2016, the performance of the project farms in 2017 showed significant reductions in pesticide cost ranging from 34% to 97%, which is a gain of 395 -1,751 ETB (US\$13.40 to US\$59.50) per hectare (ha) per season. The smallholder farm of Dansha Aurora Union recorded the highest cost savings: 1,751 ETB (US\$59.50) on pesticide costs (Fig. 2)

Environmental and Social Benefits

In addition to the economic benefits for the farms, the reduction in pesticide usage of 4.5% to 99% had significant positive effects on the environment and health of farm workers (Figs. 2-4). Interestingly, smallholder farmers achieved significant reductions in pesticide use, with some achieving zero levels hazardous pesticide use.

There were improvements in irrigation water management of the project farms in Afar. The farms improved their record-keeping and usage from an excessive (but unknown) amount of water to measured distribution. Both farms consumed about 600 M³ water per ha. Even though the farms were not paying for the water they used, optimising irrigation water had the environmental impact of reducing salinity and enhancing energy use efficiency and productivity.

Empowering Implementing Partners

The staff of implementing partners including ETIDI, WARC, ECPGEA received training on basic sustainability principles. The staff of cooperative unions and the staff, of the Hiwot, Lucy and Aweke Fente Farms, received supervisory training on the implementation of sustainability production principles. The extension agents and lead farmers received special training during the crop-development stages of cotton production. About six training sessions on good agricultural practices (GAP) were given to 25 extension agents, 76 lead farmers and 12 management staff of commercial farms. The extension

agents and lead farmers conducted 'training camps' to share knowledge and train other farmers on good agricultural practices.

The training programmes focused on better practices for sustainable crop production such as:

- Timely land preparation and sourcing of inputs,
- Identification of pests, beneficial insects, bio-intensive, IPM and rational use of chemicals,
- Irrigation water management,
- Improved fibre quality,
- Reducing contamination,
- Minimising the cost of production, and
- Maximising productivity and profit.

Lead farmers were successful in the implementation of bio-intensive practices and IPM tools to manage pest populations, with the aim of reducing insecticide use whilst maintaining profitability through enhanced yields and fibre quality.

Facilitating Market Access

The project aimed to increase the supply of sustainable and traceable cotton by securing the type of quality fibre demanded by national and international markets. The project successfully facilitated a lint-marketing agreement between Dansha Aurora Union and Kanoria Africa Textiles PLC and Lucy and AYKA Addis.

Knowledge Sharing and Upscaling

The experience gained from the two pilot regions was encouraging, based on which strategies were upscaled in other cotton-growing regions, by disseminating best practices through regional field days, as well as national and international conferences.

Progress Towards Certification

In 2017, at the beginning of the SCIE interventions, the level of compliance of the project farms toward the minimum requirements of better cotton ranged from 52% to 69%. The next year, compliance levels reached 65% to 90%, with 13% to 23% adoption rates of good agricultural practices. The remaining gap toward certification ranged from 10% to 35% (Fig. 4) to be fulfilled depending on the commitment of the project farms and project interventions during 2018 cropping season.

The two rain-fed cotton-production units — the large scale Hiwot Agricultural Mechanization PLC and the representative of smallholder cotton producers, Dansha Aurora Multi-purpose farmers' cooperative union — were ready for certification under CmiA standards in the 2018 cropping season and to fulfil the remaining less-than-11% of the gap. The irrigated farms, such as Lucy and

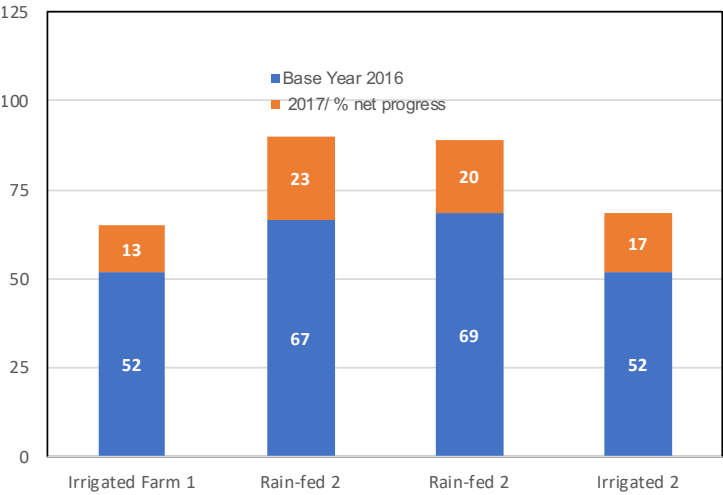


Figure 4. Progress of SCIE farms in 2016 and 2017

Aweke Fente Agricultural Development PLC in Afar, were committed to be certified by the BCI/SCS by 2018, fulfilling the remaining less-than-35% minimum requirement of better cotton.

acknowledgment

I would like to express my deepest appreciation to our funding partners EP, HandM and the Dutch government; and our implementing partners ETIDI, EIAR, ECPGEA, Dansha Aurora Union, Hiwot agricultural Mechanization, Lucy and Aweke Fente Agricultural Development PLC.

References

National Cotton Development Strategy (NCDS) 2017-2032, SOFRECO, June 2017

Measuring Sustainability in Cotton Farming Systems (FAO and ICAC) 2015

Better cotton production principles and criteria explained October 2013

National Cotton Commodity Research Strategy (NCCRS) 2016-2030, EIAR October 2016

www.bettercotton.org2014harvest report

www.bettercotton.org2015harvest report

www.cottonmadeinafrica.org/en 2014/2015



Keep abreast of ICAC news, trends and developments along the cotton value chain at:
Twitter [@ICAC_cotton](https://twitter.com/ICAC_cotton)



Visit the ICAC website where you can also subscribe to receive publications and find documents from the 78th Plenary Meeting of the ICAC.



INTERNATIONAL COTTON ADVISORY COMMITTEE