The ICAC Recorder

Perspectives on Cotton Research and Ideas for Africa- Proceedings & Recommendations of the XIV Meeting of the Southern & Eastern Africa Cotton Forum (SEACF)

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The XIV Meeting of the Southern and Eastern Africa Cotton Forum (SEACF) was held at Harare, Zimbabwe, during 4 – 6 July 2018, with a theme "Global best practices for cotton yield enhancement in Africa". Seventy-seven researchers from seven countries (Kenya, Mozambique, South Africa, Zimbabwe, India, Bangladesh and China) attended the SEACF meeting. Dr. Dumisani Kutywayo, chaired the local Organizing Committee and guided Mr. Lawrence Malinga, ARC – Industrial Crops, South Africa and Mr. Washington Mubvekeri in organizing the meeting.

Hon. Ringson Chitsiko and Kai Hughes

Background

The SEACF was founded 20 years ago. Prior to the formation of SEACF in 1997, the ICAC supported three African regional meetings; the first in 1982 in Sudan, the second in 1984 in Tanzania and third as African Cotton Conference in 1989 in Togo. Subsequently during the first World Cotton Research Conference in February 1994 in Australia, researchers from the Southern and Eastern African countries met and proposed to set up the 'African Cotton Research Network' under the aegis of the ICAC. Dr. Joe Kabissa, Tanzania was elected as the Chairman. The network was merged into SEACF in 1997 to focus more on production research instead of trade issues. So far fourteen meetings have taken place. The past six meetings were held in Tanzania (2008), Zambia (2010), Kenya (2012), Mozambique (2014), Brazil (2016) and

Map of SEACF Countries (shaded in Blue)

Zimbabwe (2018). Dr. Graham Thompson of South Africa served as the SEACF coordinator for more than 10 years. Mr. Adalberto Banze was the SEACF Chairperson of the X1Vth meeting in Harare.

Inaugural Session

Dr. Dumisani Kutywayo, chair of the local organizing committee, Mr. Adalberto Banze, SEACF Chairperson, and Mr. Kai Hughes, Executive Director, ICAC, delivered key note addresses. The Permanent Secretary Mr. Ringson Chitsiko represented the Minister of Lands, Agriculture and Rural Resettlement, Zimbabwe to inaugurate the meeting.

Members of the organizing committee: Mr Kai Hughes, Mr. Lawrence Malinga, Dr Keshav Kranthi, Mr Washington Mubvekeri and Dr Graham Thompson

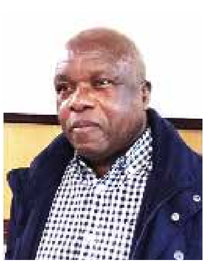
Session1: Policy Perspectives

Mrs. Nancy Zitsanza, Agricultural Marketing Authority (AMA), Zimbabwe, presented

perspectives on the cotton sector governance in Zimbabwe: policy, regulation, and national strategies. Cotton crop is grown by more than 200,000 smallholder farmers in Zimbabwe. It is a major source of livelihood for approximately 600,000 people, including farmers, farm workers, their families and industrial workers. Three farmer unions namely, ZFU, ZCFU and ZNFU are actively involved in cotton production. Independent farmer groups also get involved in cotton production and marketing. The AMA has a regulatory function. Other service providers are the Cotton Research Institute, Research Services Division, Agritex, Ministry of Lands and Agriculture, Ministry of Industry & Commerce and input suppliers. The key players in the cotton value addition are Cottco – countrywide, ETG Parrogate – Masvingo, Manicaland, China Africa – Gokwe, Alliance - Gokwe, Sanyati, Kadoma, Southern Cotton – Mbire, Muzarabani, Rushinga, Makonde and Gokwe. The National ginning capacity is 600,000 metric tonnes. The average ginning out-turn is 41% lint. Over the past seven years, area, production and yields have declined, with a slight recovery in 2017. The key issues affecting the cotton sector are; 1. Low viability of cotton production due to international prices being affected by subsidies; 2. International price volatility; 3. Low yield per hectare – Average national yield is 700kgs/ha of seed cotton despite high yield potential of local varieties; 4. High input costs; 5. Weak sustainability of contract schemes and 6. Recurrent droughts. The National strategies include comprehensive cotton production & marketing framework, cotton input support schemes and cotton to clothing strategy. There is a need to improve productivity through research and development by strengthening support to the Cotton Research Institute and Quton. Farmer training programmes can improve seed cotton yields. There are ample opportunities in the Zimbabwe's cotton industry. There is conducive climate for cotton production. Contractors could increase investment in cotton production. About 70% of cotton is exported as raw lint, though the sector yearns for increased investment in spinning, weaving and textile industry to utilize the lint that is produced. The AMA remains committed to foster the sector's growth by providing a level playing field for all the players in the cotton industry in Zimbabwe.

Mr. Michael Jenrich focused on the importance of one variety, one zone, one gin concept. He said that 10% of the world's cotton is grown in Sub-Saharan Africa (world's fourth largest cotton exporter following the USA, India and Uzbekistan). The Sahel states along the southern belt of the Sahara alone generate $1.5 billion each year by exporting raw cotton, which accounts for up to 35-75% of the agricultural export earnings in this region. In southern and eastern Africa, cotton is cultivated exclusively by smallholder farmers (3 million in number). 18 million people in Sub-Saharan Africa (SSA) depend either directly or indirectly on cotton farming. Mr. Jenrich emphasized that companies investing in production need to be certain to receive cotton, through contract compliance and also by ensuring that companies that do not support farmers can't get cotton procurement licence. A central procurement system needs to be set up so that companies get their investment back. Additionally, concessions are provided for one zone, one gin concept where only a single ginner would be allowed (accredited) to operate in defined areas. Mozambique cotton production is unique in the region, that is entirely based on a concession system. The ginning companies are granted concession and rights as exclusive buyers of seedcotton in their respective areas of concession. The overall set up is controlled and monitored by the Government. The companies get exclusive right to purchase all cotton grown within the concession area. There is support in organizing district and village task forces and farmer business groups to buyers in recovering loans. Extension package is provided to all registered cotton farmers. Extension training support is offered as a mandatory requirement to get concession. Minimum price is set up to ensure that farmers receive "fair" market price. Procurement of cotton is done at the minimum support price. Seeds, fertilizers, herbicides, improved tools etc., are supplied to farmers. Tanzania is investigating district concession, as districts are easier to manage from an administrative point of view. Single district is easier to monitor and control trade thereby reducing leakage during marketing. This makes the concession more attractive to bidders, thereby potentially getting better offers. Technical and input provision for cotton production is essential to ensure productivity and viability to producers and buyers. Individual control set ups (contract supervision and enforcement) are costly and complex. Controlled systems from field to gin can ensure investment and viability for producers and buyers. Price and service monitoring systems would need to ensure fair trading. Tendered and monitored concession set ups with exclusive production and purchasing based on investment (Gin, infrastructure and support) would need investment in production and productivity. Finally, transparent and effective monitoring of rules and guidelines are pivotal for the sector to progress.

Mr. Fungayi Simbi, Bayer Crop Sciences, proposed public & private sector interventions to improve cotton productivity in the southern & eastern African region. He highlighted the following constraints in the region: Low cotton yields and poor quality seed cotton production; lack of access to credit for key inputs in cotton production; poor funding for national agricultural extension services; lack of investment into the cotton industry; poor compliance of contract integrity by smallholder farmers; side marketing to dodge repaying cotton input advances; use of chemicals that are not recommended; repeated use of the chemicals from same group that accelerates insect resistance; lack of high yielding cotton cultivars; selling of free inputs provided by the Government and use of obsolete technology. He concluded that the collective efforts of private and public partnership resulted in increase of lint production from 25,000 bales in 2013 to 180,000 bales in 2017, investment in 3 ginneries, investment in harvesting machines to consolidate picking and baling, creation of 5,500 jobs from farm to retail and provision of funding support for 1,000 small farmers (4,500ha).



Mr. Jeremiah Tevera, Federation of Farmers' Unions (FoFU), spoke on the cotton grower's roles, challenges and expectations in the cotton sector. The cost of production has been on the rise mainly due to the increase in input cost and labour wages. Depletion of draft power due to cattle deaths, diseases and droughts esp. during the 2015/16 season were the main production constraints. Technology adoption is slow because of which the yields were low at 710 kg seed-cotton /ha during the 2016/17 season. Climate change has been causing monsoon anomalies. Input-use is as per blanket recommendations and not based on soil analysis or any diagnostic studies. He said that the Government's proposal to revive cotton is a good move, but this would be successful only when an enabling environment for private sector participation becomes operational. Further there are issues that need immediate attention. Family labour is taken for granted and includes exploitation of children and women. Exposure to harmful chemicals is detrimental to human health. There is a need for proper education and awareness programmes on compliance with labour rules and proper chemical usage. Businesses operating in cotton growing regions usually manipulate prices of inputs and other products during the marketing season to the disadvantage of producers and consumers. Government interventions would be necessary to prevent such manipulations. Extension service provision should be complementary between Government and the private sector. There are several expectations that include better yields and better prices, reasonably priced inputs available at the farm gate, private sector participation in cotton production funding, prompt payments and access to supplementary irrigation in case of dry spell. There is a need to encourage investment by supporting value chain players. Other expectations are; access to effective management practices for weed, pest and disease control; rebates on duty; import bans via improved producer prices; employment creation; reduced input costs; improvements in farmer education and production system advancements in line with regional and global trends; and export Incentive to capacitate local investment in the sector.

Session 2: Technology Transfer

Dr. Usha Rani Joshua, Central Institute for Cotton Research, India, described front-line demonstration (FLD) experience as a time-tested and successful 'transfer of technology (TOT)' practice in India and its relevance for Africa. The performance of the cotton sector in India has been quite impressive in terms of its achievements in area and production over the years. This is due to the introduction of promising genotypes and efficient production and protection technologies. FLD is based on properly defined and streamlined technology dissemination arrangements. It is a proven cotton extension mechanism with the objectives of demonstrating the usefulness of the latest improved crop production and protection technologies to the farmers as well as extension workers, with an objective to reduce the time lag between technology generation and its adoption. It also enables scientists to obtain direct feedback from cotton farmers, which facilitates reorientation of research programmes to develop appropriate need-based technology packages. FLD is generally implemented in low productivity areas. Farmers are selected by rural institutions in consultation with local leaders and agricultural officers. These officials form part of the FLD team. Bench mark surveys are conducted before taking up the demonstrations which includes information on the crops and cropping system of the area, inter cropping, average yields of cotton, local practices adopted and information on cost of cultivation. Technological interventions are planned and demonstrated by the scientists in selected farmers' fields based on problems identified. Critical inputs needed for the technological interventions are supplied and frequent field monitoring visits are made. A total of 19500 FLDs were conducted during 1996 to 2017 in eleven cotton growing states of India by sixteen participating centres with a budget outlay of US$ 1.6 Million. The FLD results were compared with yields of farms under regular practices with respect to yields, insecticide use and reduction in cost of cultivation. Results showed an average of 18.0% increase in yield. The interventions recommended to improve the status of cotton growers in Africa mainly comprise of 'farmer to farmer' technology dissemination, empowerment and capacity building of farmers, gender mainstreaming, public-private partnerships and promoting information and communication technology in technology transfer. The FLD format is most likely to suit Africa because of the identical nature of challenges in small-scale farming systems in Africa and India.

Mr. Nkosilathi Nkomo, National University of Science and Technology, Zimbabwe, enlisted technologies for the development of value-added products from cotton stalks. Cotton is cultivated primarily for fibres, and little use is made of the cotton stalks which are considered as farm-waste. Approximately two to three tonnes of cotton stalk are generated per hectare in cotton farms. Approximately a million tonnes of cotton stalks are produced in Zimbabwe every season. During the off-season, cotton stalks provide shelter to pathogens and insect pests such as mealybugs and pink bollworms. Generally, stalks are burnt thereby causing environmental pollution. Approximately 0.85 million metric tonnes of CO_2 is produced per million metric tonnes of cotton stalk burnt. Cotton stalks can be used to manufacture particle boards, preparation of pulp and paper, hard boards, corrugated boards & boxes, microcrystalline cellulose, cellulose derivatives as substrates for growing edible mushrooms, organic fertilizers for soil amendment and soil incorporation to improve micro-organism activity and increase seedling growth. These different uses can add value thereby increasing profit margins of farmers to enhance the viability of cotton farming in Zimbabwe.

Dr. Richard Musebe, CABI, Kenya, described initiatives on integrated crop management, pest management, technology transfer and capacity building in smallholder cotton production systems in Kenya. Agriculture contributes 24% to the GDP and 80% of the rural population relies on agriculture as the primary source of livelihood. Eighty per cent (80%) of the land mass in Kenya is dry land; hence only 20% that is arable land is used to feed a population projected to increase to approximately 60 million by 2030. Cotton thrives well in the arid and semi-arid dry land (ASAL) thereby enabling effective use of land that would otherwise be unsuitable for some crops. Cotton provides raw material for multiple industries and thus holds the key for employment, incomes and poverty alleviation. The seed-cotton productivity is low at 488 kg/ha due to poor quality seeds, poor land preparation and declining soil fertility. Pest control is grossly inadequate, though pests account for 20-30% of the total production costs. Farmers have limited knowledge and inadequate technical support that lead to low adoption of technologies. Improving capacity of farmers is critical for better cotton production. It is also necessary to strengthen linkages between the actors in the cotton value chain. Dr. Musebe discussed the transfer of integrated crop and pest management strategies, and suggested measures that would most likely meet the needs of target farmers. He underscored that institutional learning and associated changes are vital elements for successful technology dissemination. He observed that aligning technology attributes with end-user preferences can accelerate uptake. It is important to enhance farmer participation so that farmers are part of the solution rather than just being passive recipients of knowledge that can improve uptake of technologies. This can be facilitated by improving access to capital and finances by linkages with financial institutions. He concluded that efforts aimed at increasing ownership of technologies by farmers in the initial instance can enhance uptake thereby leading to improved cotton productivity.

Session 3: Plant Breeding

Mr. Manuel Maleia, Centro de Investigação e Multiplicação de Sementes de Algodão de Namialo, Mozambique, examined stability and adaptability of cotton genotypes under multi-environmental conditions in Mozambique. He tested the adaptability and performance of 15 new genotypes in comparison with three checks. Maleia concluded that the seed cotton yield is highly affected by environment complex than genotype itself. Among the new genotypes, IMACD 06-6798, IMA1 08-3917 and BA919, were found to have an acceptable adaptability and potential stability.

Mr. Maco Mare, Cotton Research Institute, Zimbabwe, presented results on determining adaptability of medium staple *G. hirsutum* genotypes to the agro-ecological conditions of the Lowveld in Zimbabwe. Cotton variety development in Zimbabwe requires that test genotypes undergo multi-environment evaluation and selection in marginal growing conditions such as the ones in Lowveld. Superior cotton varieties for the Lowveld were identified through field experiments conducted for four seasons from 2013-17. Eight genotypes were code-named 830-01-3, 89-01-2, 85-01-1, 831-01-3, 820-01-1, 812-01-3, 830-01-7 and 83-01-4, to be compared with three standards namely SZ9314, CRI-MS-1 and CRI-MS-2. Seed cotton yield, lint yield, ginning out-turn, boll weight, seed weight, earliness, staple length using the upper half mean length (UHML), micronaire, length uniformity, strength, elongation and fibre maturity were measured. Results revealed no significant 'genotype x environment' interaction for all traits. Genotypic differences were observed on boll weight, seed cotton yield, lint yield and seed weight whilst the other field parameters had no significant differences. Genotypes 83-01-4 and 89-01-2 had the highest seed cotton yields of 1896kg/ha and 1888kg/ha respectively. These also had the highest lint yields of 690.50kg/ha and 694.50kg/ha respectively. No significant differences were observed on all fibre characteristics. All the varieties were within the range of global standards on staple length, micronaire and elongation although 812-01-3 performed poorly with 5.9% elongation. The varieties had good fibre strength which was above the standard of 30g/tex and good maturity above 0.85. Stability analysis using genotype and genotype by environment interaction (GGE) revealed that 83-01-4, 89-01-2 and 830-01-3 were more stable and adaptable in all environments. In conclusion, two genotypes, 83-01-4 and 89-01-2 were identified which were suitable for the lowveld conditions based on the field performance and fibre qualities.

Mr. Kudzai Mandiveyi, Mahyco seed company, presented results of field trials conducted with new Mahyco cotton hybrids for Zimbabwe and Africa. He proposed commercialisation of 6 new hybrids based on their yield superiority over checks by 12-24%.

Dr. Ye Wuwei, State Key Laboratory of Cotton Biology, China, described cloning and expression of drought & salt-tolerant genes in cotton. Abiotic stress (water deficiency and soil salinity) has become a serious global problem affecting the agricultural development and the ecological environment. Salinity is one of the most important abiotic stresses in the world, that severely limits the production of crop. Salt-tolerant cotton cultivars can play a vital role in combating the problem of salinity. The conventional methods of screening cotton genotypes for abiotic-tolerance are laborious and time-consuming. Identification of genes can accelerate the development of salt-tolerant cultivars. Seven salt-tolerance related genes, H^+-pyrophosphatase gene and S-adenosylmethionine synthetase gene and others, were cloned from salt-tolerant varieties of *Gossypium hirsutum*, which were named *GhVP, GhSOS1* and *GhSAMS,* respectively. These genes are being utilized to develop salinity resistant cultivars.

Session 4: Agronomy

Dr. Blaise Desouza, Central Institute for Cotton Research, India, emphasized the importance of conservation agriculture for sustainable cotton production in Africa, based on Indian experiences. Cotton is a commercial crop supporting the livelihoods of millions of farmers in Africa. However, productivity levels are low. Low soil fertility, soil degradation, rain dependence and biotic stresses are some of the key factors responsible for low crop productivity. Furthermore, majority of the farmers belong to the small holding category with limited resources. In such situations, adopting the Best Management Practices (BMP's) can help address this challenge. Conservation Agriculture (CA) is one of the major components of the BMP that holds the key to improving productivity. CA revolves around three basic principles: (i) minimizing tillage, (ii) including a permanent cover and (iii) Crop rotation. Experiences in India indicate that CA is more sustainable and has a wider adaptation because it improves soil quality and crop productivity. Thus, CA systems are best suited to the African countries since soil and water is conserved and improves livelihoods. The results of the CA systems in cotton in India and those of other parts and Africa were summarized. Although, most of the studies indicate synergism when the three technologies are used in combination; there are instances where the CA systems were inappropriate. For instance, in southern Zambia, CA systems had poor yield levels compared to the conventional farmers practice. On the other hand, in Cameroon, CA systems were found to have a positive impact. It is important to understand that a CA technology developed in a region cannot be directly used elsewhere. We need to understand the local situation (soil, climate) and tailor the CA practices to suit the local conditions. Therefore, it is important to learn and adapt to the local conditions by innovating technologies to make it acceptable to the farmer. Full paper by Dr. Blaise on the subject will appear in the December 2018 issue of the ICAC Recorder.

Dr. Matilda van der Westhuizen, ARC-Institute for Industrial Crops, South Africa, evaluated cotton cultivars under irrigation in the southern region. The cultivars DP1240 B2RF, DP1531 B2RF, DP1541 B2RF, Delta 12 BRF, Candia BGRF and Carla were tested during the 2016/2017 growing season in Loskop (Mpumalanga province), Vaalharts and Upington (Northern Cape). Fibre yields differed significantly at different locations and with different cultivars. At Loskop, the highest fibre yield was obtained with DP1541 B2RF (1175 kg ha^{-1}), followed by DP1240 B2RF with 1101 kg ha^{-1}. Yields at Loskop were below average as there was a very high infestation of Cotton stainers. At Vaalharts, fibre yields differed significantly. The highest fibre yield was obtained with Candia BGRF (2141 kg ha^{-1}), followed by DP1240 B2RF with 2074 kg ha^{-1}. Although fibre yield did not differ significantly at Upington, the two best performers were DP 1240 B2RF (2887 kg/ha) and DP 1531 B2RF (2842 kg/ha). The lowest fibre yield was obtained with Delta 12 BRF (2414 kg/ha).

Dr. Md. Farid Uddin, Cotton Development Board, Bangladesh, described cotton seedling transplantation techniques for adaptation to climate change. Bangladesh is one of the wettest countries of the world where a long duration of heavy rainfall is very common. The mean annual rainfall over the country ranges between 2320-6000 mm. June-August is the peak period of rainfall which coincides with the sowing period of upland cotton. As a consequence, fields remain unsuitable and unmanageable for cotton sowing. To overcome this barrier, cotton seedlings were grown in seedbeds covered with polythene mulch and transported to the main field during favourable conditions for transplanting. In 2017-2018, on-farm trials were conducted to identify the most suitable age of seedlings for transplantation. The effect of 4 different seedling ages at transplantation viz. 10, 15, 21 and 28 days on seedling survival rate, yield contributing characters, seed cotton yield and farmers net income was evaluated. Results revealed that seedling age at transplantation significantly affected the seedling survival rate, cotton yield, yield contributing characters and farmers net income. The highest seedling survival rate (98.4%) and the highest seed cotton yield 5.75 t ha^{-1} was obtained when 10-day old seedlings were transplanted, that also gave the highest net income (US$ 2707 ha^{-1}). Thus, the study showed that the optimum age for cotton seedling transplantation was 10 days and with the increase in the age of seedlings used for transplantation, seed cotton yield and farmers net income reduced significantly.

Ms. Cheidza Gwiranenzara, Cotton Research Institute, Zimbabwe, described the impact of conservation agriculture on cotton productivity. Cotton is traditionally cultivated on conventional tillage systems in Zimbabwe which exposes the soil to

degradation on a wide scale due to the slow growing nature of the crop during the first six weeks (Cotton handbook, 1998). Unless concerted measures are undertaken to address soil degradation resulting from overworking of the soil in conventional tillage systems, arable land shortages will seriously become a problem in the major cotton growing areas in the near immediate future. In recent years, technologies such as development of drought tolerant crops, conservation agriculture and moisture conservation techniques have been developed as remedial measures to mitigate the impact of climate variability. In Zimbabwean cotton, conservation agriculture is in its infancy. A study was therefore carried out to determine the benefits of conservation tillage technologies on seed cotton yield under Zimbabwean conditions. Experiments were carried out at Cotton Research Institute, Umguza, Wozhele, Shamva and Dande communal areas for three seasons during 2015 to 2017 in a randomised complete block design with five replications under conventional tillage practice, basins, ripped rows and dibbler made holes. Results showed that the highest seed cotton yield of 3002 kg/ha was achieved under basins in 2016 season. This yield was comparable to the yields obtained under ripped rows and dibble made holes at the same site and during the same season. Thus, conservation agriculture practice was identified as a promising technology that can be used in cotton production in Zimbabwe with benefits being apparent with time.

Session 5: Crop Protection

Prof. Yuan Youlu, State Key Laboratory of Cotton Biology, China, presented results on genome wide quantitative trait loci (QTL) mapping for resistance to *Verticillium* wilt (VW), fibre quality and yield traits in cotton chromosome segment substitution lines. The development of Chromosome Segment Substitution Lines (CSSLs) from *Gossypium barbadense* in *G. hirsutum* background provided ideal mapping populations for further genome research and crop improvement through marker assisted selection (MAS). Back-cross-Filial $BC_5F_{3:5}$ population with the donor parent Hai1 and the recurrent parent CCRI36 were developed. 300 CSSLs and their two parents were planted in a randomized complete block design with 2 replications in two different ecological locations (Anyang and Xinjiang) in 2015 and 2016, respectively. Phenotypic evaluation included *Verticillium* wilt resistance (disease index), fibre yield (plant height, boll weight, lint percentage and seed index) and fibre quality (fibre length, fibre strength, micronaire, fibre uniformity and fibre elongation) parameters. *Verticillium* wilt resistant materials were collected during July and August in the field. A total of 597 pairs of simple sequence repeats (SSR) markers screened from 2292 pairs of markers in the high-density map from a BC_2F_1 population of *G. hirsutum*×*G. barbadense* were used to identify polymorphisms among the $BC_5F_{3:5}$ lines. A total of 56 QTLs for *Verticillium* wilt resistance were detected; 30 of which were stable and 38 QTLs (68%) had negative additives effects; which indicates that the *G. barbadense* alleles increased *Verticillium* wilt resistance and decreased disease index (DI) by about 2.64 to 13.23. By meta-analysis, 30 QTL hotspot regions for VW resistance were identified and 13 of them were new hotspot regions. A total of 191 QTLs were detected for fibre yield and fibre quality, of which 98 were for fibre quality traits and 93 for yield related traits. 54 of these QTLs were stable. Three chromosomes, Chr05, Chr10 and Chr20 contained more QTLs. 30 clusters with disease index and fibre related traits were identified on 16 chromosomes. Most of the fibre traits were clustered with the disease index stable QTLs. We found 6 clusters namely, C01-cluster-1, C05-cluster-4, C07-cluster-1, C19-cluster-2, C22-cluster-1 and C22-cluster-2, which had positive correlation between VW resistance and fibre quality traits. Two clusters, C10-cluster-1 and C25-cluster-1 had also positive correlation between VW resistance and yield related traits (boll weight and lint percentage). One cluster, C20-cluster-1 is important for VW resistance, fibre quality and fibre yield. It is concluded that these clusters and related QTLs are very important for breeding improvement of fibre quality, yield and Verticillium wilt disease resistance.

Mr Fredy Musiniwa, Cotton Research Institute, Zimbabwe, measured tolerance levels of pre-released *Gossypium hirsutum* L. genotypes to a soil borne fungal pathogen *Verticillium dahliae* Kleb. *Verticillium* wilt is one of the most important diseases of cotton which affects yield and fibre quality in cotton across the world. The pathogen is capable of infecting plant roots throughout the growing season and persists in the soil for long periods of up to 10 years. Once *Verticillium* wilt is introduced into the field, it is difficult to eradicate because of its saprophytic ability. There is no chemical control for the disease. The disease can best be controlled by planting tolerant varieties. Experiments were conducted at Cotton Research Institute for three seasons to screen promising cotton genotypes for natural defence against *Verticillium* wilt in a field with a long history of infection by the pathogen. The experiments were laid down in Randomized Complete Block Design (RCBD) with 12 treatments replicated 3 times. Disease incidence, disease severity and

seed cotton yield were measured. Disease severity was scored using a scale of 1-5, while incidence was scored using percentage infection. The results showed that the promising genotypes had different tolerance level to the pathogen. Genotypes: 931-05-1, GN96(b)-05-8, 919-05-2, 932-00-3, 648-01-4 and 562-00-9 showed high tolerance levels to the disease and are therefore suitable for further breeding advancement.

Session 6: Best Practices for Yield Enhancement in Africa

Papers are presented as separate chapters in this issue.

Dr Isaiah Mharapara conducting an interactive session

Session 7: Biotech Cotton Practical Workshop & Interactive Session

Dr Keshav R Kranthi conducted participatory practical sessions on *Bt*-detection using immuno-chromatographic strips and *Bt*-quantification through Enzyme Linked Immuno-sorbent Assay (ELISA).

Dr Keshav R Kranthi, ICAC, presented two talks. The first talk titled 'Secrets of high yields' dealt with the main principles of best practices that are used by the top 5 cotton productive countries. The second talk 'Biotech cotton -Africa' dealt with the details of biotech cotton products available across the world and the relevance for the major cotton producing countries of Africa.

Recommendations

- Yield enhancing strategies: Cotton yields in Africa are low and have been stagnant for about three decades. Plant breeding and agronomy efforts must be oriented towards breeding of 'efficient' plants with compact architecture, short duration that possess capacities for higher 'nutrient-use efficiency' and 'water-use-efficiency' due to a much shorter critical window of boll formation compared to the current 'inefficient' long duration cotton production systems in Africa. Research across the world has shown that short season, early maturing, compact plant types when planted under high density result in higher yields in a shorter time and have the potential to escape biotic (pests and diseases) and abiotic stress (drought).
- Support for Research: There is a need to strengthen cotton research institutions by improving infrastructure facilities and human resource development through consolidation of local expertise, knowledge and also overseas training in advanced technologies.
- Demand driven technologies: African farmers need comprehensive cotton production packages that protect them from weather vagaries. Research institutions in the respective countries must strive to develop climate resilient, sustainable, environment friendly, demand driven, locally adaptable technologies. Technology adoption is easiest when they are demand-driven. However, the adoption of many agricultural technologies is slow either because they are expensive or are not designed to solve the local problems. Aligning technology attributes with end-user preferences can greatly enhance uptake. In this process, it is important to enhance farmer participation so that farmers are part of the solution rather than just being passive recipients of knowledge that can improve uptake of technologies. Efforts aimed at increasing ownership of technologies by farmers in the initial instance can enhance uptake thereby leading to improved cotton productivity.
- Crop protection: Insect pests and diseases cause significant economic losses thereby resulting in low yields in Africa. In many cases poor access to pest control technologies or inputs or lack of access to credit for key inputs in crop protection leads to crop damage. There is a need for Governments and private agencies to facilitate timely and affordable access to effective weed, pest and disease management practices according to the principles of integrated pest management and Insecticide resistance management.
- Seed quality: Yields can be greatly enhanced with good seed quality. Organised production of good quality certified seed has the potential to transform cotton production in Africa.
- Sustainable inputs: In many African countries, technological inputs such as fertilisers, pesticides and farm machinery are scarce. To ensure environment

friendly farming and sustainability, farmers must be provided with access to biological inputs for pest and nutrient management under cotton input support schemes that incorporate components of integrated pest management and integrated nutrient management.

- Sustainable brand: Cotton is completely rain dependent in Africa (Except in South Africa, Egypt and Sudan and some parts of Ethiopia, Kenya and Nigeria). In all other countries where cotton is 100% rainfed, opportunities must be explored to develop organic cotton or sustainable cotton production systems that create 'sustainability brands' to fetch higher prices in the global market.
- Conservation agriculture (CA): Cotton cultivation in Africa is based on conventional tillage systems, which lead to soil degradation. Conservation agriculture is best suited to the African countries, since the technology is not input intensive and results in the conservation of soil and water through inexpensive approaches, which improves yields and livelihoods in small-scale farming systems. It is important to understand that a CA technology developed in a region cannot be directly used elsewhere and that the CA practices must be tailored to suit the local situations based on the soil type and climate. By innovating locally relevant CA technologies, it will be possible to gain farmer acceptance.
- Fibre to fabric: Cotton generates enormous employment opportunities. There is a need to encourage private investment and Government support for the textile industry. It is estimated that one tonne of cotton provides annual employment to at least 5-6 persons. About 80% of the raw cotton produced in Africa is exported. The raw cotton produced in Africa has the potential to employ 8-10 million persons all through the year in the textile value chain. Cotton producing countries in African must seriously contemplate on setting up textile mills, which would not only generate employment but can enhance revenues by 8-fold to 20-fold or more depending on the type of value-added products produced such as yarn, fabrics, textiles and apparel.
- Wealth from waste: Value addition to cotton farm waste can improve the status of cotton growers in Africa. Instead of being burnt, cotton stalks can be used to manufacture particle boards, preparation of pulp and paper, hard boards, corrugated boards & boxes, microcrystalline cellulose, cellulose derivatives as a substrate for growing edible mushrooms, organic fertilizers for soil amendment and soil incorporation to improve micro-organism activity and increase seedling growth. These different uses can add value thereby increasing profit margins of farmers to enhance the viability of cotton farming in Africa.
- Technology transfer: Farmer training programmes can improve seed cotton yields. There is a need for proper farmer education and technology awareness programmes. Extension services become confusing when there are conflicting messages from the private input providing companies and public sector agencies. It is important that a standard technology curriculum is developed for the country and technology transfer is made complementary between Government and the private sector. Novel methods such as 'farmer to farmer' technology dissemination, empowerment and capacity building of farmers, gender mainstreaming, public-private partnerships and promoting information and communication technology in technology transfer should be initiated in Africa. The front-line demonstration format which has been highly successful in India, is most likely to suit Africa because of the identical nature of challenges in small-scale farming systems in Africa and India. Funding for national agricultural extension services would result in effective technology transfer.
- Business opportunities: Currently chemical inputs such as fertilizers and pesticides are imported into Africa and become more expensive due to additional transport costs. Non-chemical technologies for pest management and nutrient management have been developed across the world. Technologies such as biological control, biopesticides, biofertilizers, production of biochar etc., can be generated in the public sector and private sector research institutes and these biological products can be manufactured locally, to create business, employment opportunities and revenue. Contractors could increase investment in cotton production based on the local technologies.
- Marketing support: African farmers need robust marketing support policies that shield them from price fluctuations and market uncertainties. Poor compliance of contract integrity by smallholder farmers is a common phenomenon in Africa and other developing countries, wherein farmers resort to side marketing to dodge repayment of cotton input credit. Contractors need to be insured against side marketing by farmers. Private companies operating in cotton growing regions usually manipulate prices of inputs and other products during marketing season to the disadvantage of producers and consumers. Therefore, it is important to ensure fair trading practices to protect farmers from being exploited by traders and middle-men. Price prediction and trade monitoring systems would be needed to ensure fair trading. Transparent implementation of rules and guidelines will greatly enhance credibility and trust in transactions and trade.