Hope and Scope for Enhancing Cotton Production in Africa

M. Sabesh, ICAR-CICR, Regional Station, Coimbatore, Tamil Nadu, India. E-mail: sabesh23@gmail.com

Introduction

Africa's agriculture is dominated by a variety of staple food crops (maize, rice, sorghum, millet, cassava, yam, sweet potato, etc.) and a few traditional cash crops (coffee, cotton, cocoa, palm oil, sugar, tea, and tobacco). Cotton has been depicted in some studies as "the mother of poverty" (Isaacman, 1980). In contrast, other studies have described cotton as "the white gold" (Tefft, 2010; Kranthi, 2015).

Cotton is a major source of foreign exchange earnings in more than 15 African countries and a vital source of cash income for millions of rural people. Cotton plays a significant role in the fight against rural poverty in Africa. Of the 30 leading cotton-growing countries in the world, 12 are from Africa (ICAC). Cotton production has been a major economic component in terms of export earnings in several African countries over the past few decades. The cotton production and marketing sectors are considered as paradigms for agricultural commercialisation and industrialisation in African cotton-producing countries, especially in Benin, Burkina Faso, Chad and Mali, often called the 'cotton four' or 'C4' countries (Badiane *et al.,* 2002; Gergely and Poulton, 2009).

Stagnant yields and increasing input costs have made cotton cultivation less sustainable in Africa over the past three decades. This could be due to many factors related to the ecological conditions where cotton is cultivated, or the socio-economic conditions of small-scale farmers. But by and large, policy decisions over the period across African countries appear to have been ineffective in enhancing the profitability and sustainability of cotton production.

A review of various dossiers related to cotton in Africa shows that there is commonality in constraints connected with a financial crunch in production, poor crop management, weak extension systems, disorganised cotton procurement, and amorphous marketing and export. Cotton farmers in Africa face three main constraints:

- Low yields,
- Non-remunerative prices, and
- Cotton area replacement by food crops.

Several projects on reforms and technological interventions in cotton production were implemented by different global agencies in different countries of Africa during the past 3 to 4 decades. However, there has hardly been any perceptible change in the cotton fibre quality or yields. Despite external aid and support and innumerable internal policy interventions in major cotton-producing countries, cotton-production systems do not seem to have benefitted much.

Over the years the farming community in Africa has been in a precarious state in which their income doesn't match with the increasing inflation, which affects their standard of living. Although the African countries produce excellent-quality raw cotton fibre for the improved lifestyle of the most modern and civilised societies across the world, many in Africa continue to be deprived of basic clothing. In most of the African countries, farmers still do not earn enough to support basic education, nutritious food and good health care.

Over the past five decades, cotton farming underwent several turbulent phases in almost all cotton-growing countries in Africa. Low yields and low profitability have rendered cotton farming unsustainable in Africa in recent times. This paper analyses the core issues and recommends best practices that were drawn from successful examples across the globe. It describes the hope and scope to improve the cotton production systems in Africa.

Cotton Scenario in Africa

Cotton is grown in small-scale farming systems, predominantly under rainfed conditions, where it is grown along-with food crops mainly sorghum or maize. Traditionally, due to colonization by foreign rulers, cotton production systems have been based on contractual basis. Coordination between cotton cultivators and cotton companies has evolved into contractual arrangements wherein, the cotton companies provide inputs in the form of seed, pesticides, fertilisers, and extension services and purchase all cotton produced by cultivators at agreed prices (Badiane et al., 2002; Silvie et al, 2001).

The cotton scenario in African countries underwent formidable changes in the past decades. There was a significant shift in the cotton cultivation scenario in Africa after 1960. Over the past 4-5 decades, cotton area in Francophone Africa increased three-fold whereas the area in north Africa plus eastern and southern Africa reduced to less than half. During the 1960s, the Eastern African countries occupied an average area of 75% of the total cotton area in Africa, but the share decreased to

37% between 2010 and 2017 (Table 1), whereas during the same period the WCA (Francophone) countries enhanced the area under cotton from 24% to 62%. In the early 1960s Egypt cultivated cotton in about 0.8 million hectares (ha.) and in the early 1970s Uganda was a major cotton cultivator, with an area of 1.0 million ha (ICAC data). From 1964 to 1987, the average cotton area in southern and eastern Africa was 1.52 million hectares, whereas the average area in Francophone countries, including the C-4 countries (Burkina, Mali, Benin and Chad) was 0.67 million hectares. For the period between 1964 and 1987, north Africa and southern and eastern Africa together had an average area of 2.52 million hectares under cotton. In 2017, the average cotton area in Francophone countries was 2.80 million hectares while the combined average cotton area in north Africa and southern and eastern Africa was 1.19 million hectares.

Notably after 1980, cotton cultivation shifted predominantly from Eastern and Southern Africa (ESA) to Western and Central Africa (WCA). In the 1980s and thereafter the area under cotton was drastically reduced in Uganda and Egypt. The C4 countries consolidated their position as the leading cotton cultivating countries in Africa, especially between 2010 and 2017. Currently, Francophone countries including C4 countries occupy 66% of the total cotton area in the continent, but contribute to 72% of the cotton production. Due to the predominant shift in cotton cultivation domains in Africa (Figure 1), the pattern of cotton production also got relatively transformed. ESA countries reduced their average cotton production from 85% in 1960s to 34% between 2010 and 2017, in contrast, the WCA countries increased the share of their cotton production basket in Africa from 15% to 66% during the period.

Export of cotton from ESA countries decreased from 85% in 1960s to 28% over the recent past. Traditionally, due to the lack of cotton processing and value addition, the WCA countries also export their raw cotton. In 1960 these countries cotton exports increased from 15% to 71% of the total export from Africa in last decade. In 2017, the WCA countries increased their export share to 10.05 lakh tonnes, which is equivalent to 80% of the total exports from Africa.

Among African countries, Egypt, South Africa, Nigeria, Kenya, Tanzania and Ethiopia have been the major consumers of raw cotton. About 70% to 90% of the cotton produced in these countries is utilised by the domestic textile industry. As the present research and environment conditions are improving in WCA countries, cotton productivity is also proving to be superior compared to the ESA countries. Apart from Egypt, where the agroecological conditions are totally different from other cotton growing countries of Africa, the productivity in WCA countries has been comparatively good, especially in the past 20 years.

Varietal Improvement and Seed Technologies

Seed is a commodity that is both an input and an output of the agricultural production system, and whose quality and quantity depends on management technologies. Providing seeds of adapted cultivars and good-quality seeds to farmers is essential to ensure productive and remunerative returns to farmers, traders and other stakeholders. It is appropriate to expand seed development and distribution processes — including fostering public-private partnerships — in order to make high-quality cotton seeds available to diversified agro-ecosystems, with strict quality control measures by government agencies (Charles *et al.,* 2012).

The introduction of an upland variety called Allen Long Staple from the USA to Africa in the beginning of the 1900s proved to be a highly significant event. Since then, numerous genetic materials or varieties have been derived from the genetic background of Allen. Early in the 1960s, a well-coordinated parastatal cotton industry model in WCA promoted cotton

Table 1: Decadal percent share to total African cotton

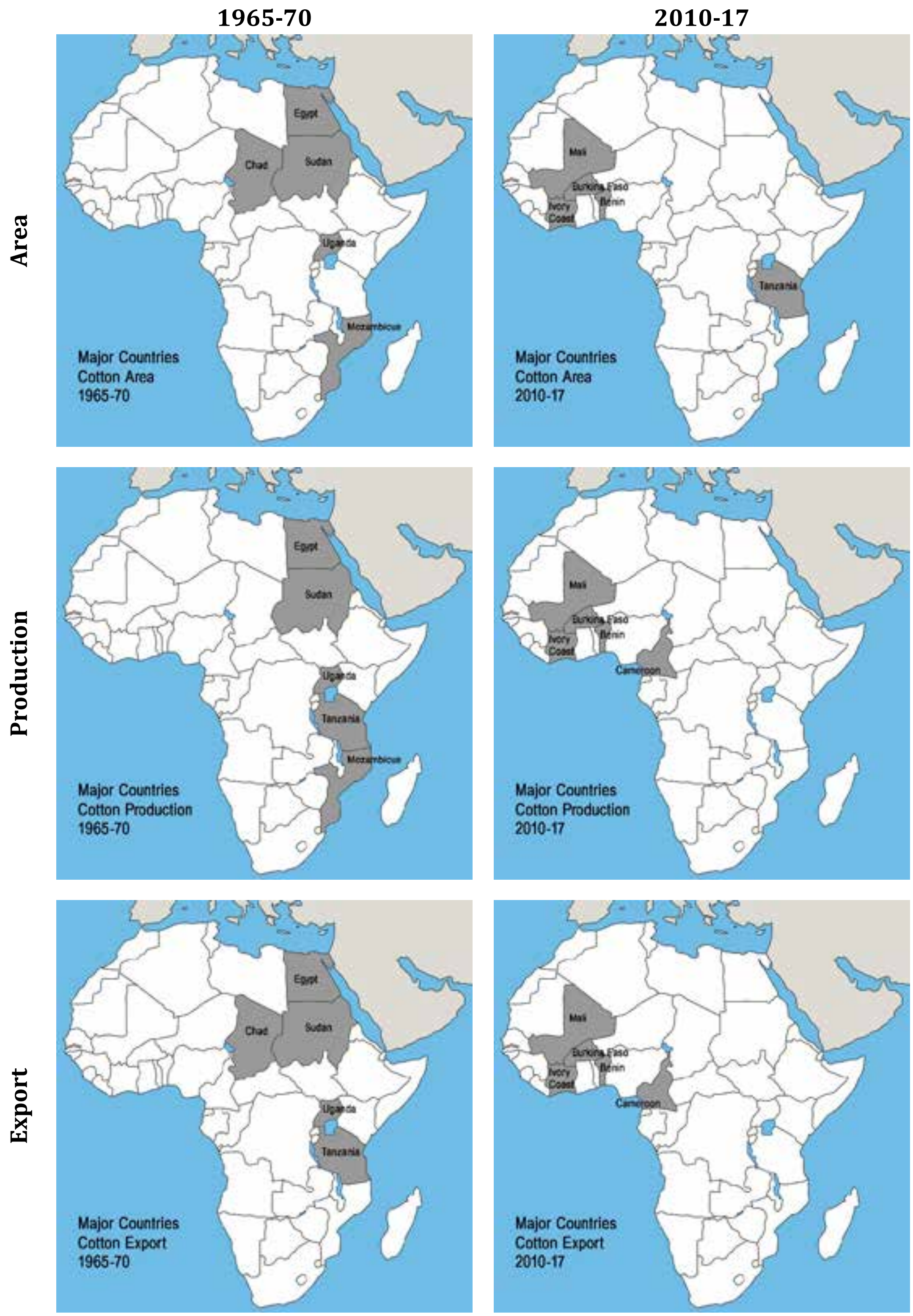
	1965-70	1971-80	1981-90	1991-2000	2001-10	2010-17
Area						
Western and Central Africa[1]	24.82	31.25	36.00	51.60	55.09	62.37
Eastern and Southern Africa[2]	75.18	68.75	64.00	48.40	44.91	37.63
Production						
Western and Central Africa	14.69	19.66	30.64	52.50	57.48	65.84
Eastern and Southern Africa	85.31	80.34	69.36	47.50	42.52	34.16
Export						
Western and Central Africa	15.21	21.90	41.92	69.38	66.57	71.89
Eastern and Southern Africa	84.79	78.10	58.08	30.62	33.43	28.11
Domestic consumption						
Western and Central Africa	10.69	15.95	15.58	19.79	19.41	12.44
Eastern and Southern Africa	89.31	84.05	84.42	80.21	80.59	87.56
Average Yield (kg/ha)						
Western and Central Africa	243	274	387	405	376	348
Eastern and Southern Africa	270	298	307	315	378	391

Source: Compiled by author; Data source: ICAC, 2018

[1]Western and Central Africa major cotton growing countries: Burkina Faso, Mali, Benin, Cameroon, Chad, Nigeria, Togo, Senegal and Cote d'Ivoire

[2]Eastern and Southern Africa major cotton growing countries: Zimbabwe, Zambia, Mozambique, Tanzania, Malawi, Uganda, Kenya, Sudan Egypt, South Africa and Ethiopia.

Figure 1. Change in African cotton scenario



cultivation and facilitated the sector's growth (Baffes, 2007). The model clearly contributed to the organisational stability of cotton research when compared with ESA, in addition to providing farmers with equipment and extension advice, thereby enabling them to adopt research recommendations (Tschirley *et al.,* 2009).

A review of different studies indicates that there has been less focus on cotton breeding or improved varieties being introduced in Africa. This is perhaps due to reduced investment by governments and private cotton companies in varietal research (Tschirley *et al.,* 2009). The African countries mostly depend on other countries outside of Africa for cotton varietal improvement programme or improved varieties. The Brazilian Government introduced nine Brazilian varieties developed by *Embrapa* into C4 countries.

In Mali, the varieties BRS 286, BRS 293, BRS Araca, BRS Aroeira, BRS Buriti, BRS Cedro, BRS Jatoba, BRS Safira and BRS Serido were introduced. The variety BRS 286 performed well with an average yield of 3,000 kg/ha in 2009 compared to 1,000 kg/ha of local varieties (WTO, 2011). The variety BRS 293 proved to be fairly good and productive. It was popularised in different names in Burkina Faso (FK37), Mali (NTAL 100) and Benin (H279-1) (Bourgou and sanfo, 2012). In the early 2000s in Burkina Faso, *Bt*-cotton varieties that were developed elsewhere, were evaluated under Burkina Faso's growing environment. Adoption of *Bt*-cotton reduced insecticide applications from 6 to 7 per season to 1 to 2, apart from resulting in yield enhancement of 15% to 35% (Baghdadli *et al.,* 2007).

However, in the recent past, it was found that the fibre quality of *Bt*-cotton varieties was inferior to traditional non-*Bt* varieties. Though the *Bt* technology in cotton was *per se* efficient in controlling bollworms, incomplete introgression and improper selection in breeding methods are presumed to have caused problems with fibre quality. Many studies and reviews mentioned that *Bt*-cotton technology is more input oriented and is therefore ideally suited for irrigated conditions (Narayanamoorthy., 2006, Ashok Gulati 2011, and Sabesh *et al.,* 2014). This may also be one of the reasons for yield stagnation in Burkina Faso, where cotton is completely rainfed.

Varietal development programmes in Africa should consider socio-economic and agro-ecological conditions of the farmers, while governments should devise policies that ensure good prices based on high-quality fibre. For example, in Mali, a new cotton variety was introduced with an increased ratio of fibre to seed. Such varieties are most preferred by ginners, but farmers complained that the weight of their seed cotton production, on which their cotton earnings depend, was less with the new variety (Valerie *et al.,* 2011).

Agronomic Practices

Many agronomic practices and nutrient- and water-management technologies have been developed and tried in African countries. Fertilisers and manures are beneficial not only to cotton but also to the food crops that are part of the cropping pattern (Quola, 2008). Inorganic fertilisers have been advocated in order to counterbalance losses of mineral elements necessary for crops included in the traditional cropping pattern. However, due to high costs, the application of chemical fertilisers is rarely followed. Ripoche *et al.,* (2015) found that a combination of inorganic and organic fertilisers is the best option to rebuild and maintain the sustainable productivity of some countries in West Africa, which have low levels of organic matter. The study also concluded that inorganic fertilisers applied to rotations of cotton with food crops help improve and maintain soil fertility.

Numerous studies have shown that pruning of sympodial branches and mechanical topping of the main stem have been practiced to control excessive growth, increase earliness, and improve yields. This technique facilitates increased supply of nutrients to reproductive parts of the plant. China has been adopting this technique extensively to increase yields (Dai and Dong, 2014). The topping technique could be ideal for African countries due to small farm holdings and abundant labour availability. In contrast, Renou *et al.,* (2011) mentioned that cotton topping in Mali had no significant effect on cotton yields, but reported that the infestation of *H. armigera*, *Earias* spp., and *D. watersi* bollworms was significantly reduced. However, it must be remembered that canopy management is an art that emanates from diligent science. The beneficial effects from pruning or topping will depend on many critical factors, such as the proper stage of the crop and the methods followed.

Conservation tillage, which involves ploughing before planting, with a no-till plus mulch method used after planting, was introduced a few years ago in Mozambique, Malawi, Ghana and other African countries. It resulted in high yield gains in maize and is spreading to cotton areas with the promise of reducing labour costs while decreasing soil erosion and increasing fertility (Ito *et al.,* 2007). Conservation agriculture in cotton is well suited in African conditions and involves dry-season land preparation, early planting, early weeding, precise field layout, and careful input application that coincide with best management practices in cotton production.

In Mali, smallholders are more likely to use no-till practices, while resource-rich farmers — who have better access to land, animal traction, equipment and fertilisers — have largely discarded the no-tillage method. In Benin, farmers use organic fertilisers mixed with inorganic fertilisers in differing proportions, often combining this with ridging and mounding (Saidou *et al.,* 2004). In

Burkina Faso, in maize-cotton crop rotations, farmers have used minimum tillage with a combination of organic and inorganic fertilisers (Ouattara *et al.*, 2006). Conservation agriculture practice in Zambia involves a package of several key practices including minimum tillage; crop residue retention; nitrogen-fixing crop rotations; and application of reduced (but precise) doses of mineral fertilisers (Grabowski *et al.,* 2014). Conservation farming in Zambia resulted in yield increases ranging from 25% to 50%. Econometric analysis separating the impact of the tillage method from other practices indicates average yield increases to 1,650 kg/ha, of which 750 kg/ha could be attributed to tillage methods alone (Haggblade *et al.,* 2010; Tschirley, Zulu, and Shaffer 2004).

Organic fertilisers (animal manure, crop residues, and green manure) have been promoted as essential complements to inorganic fertilisers because of their capacity to build soil organic carbon, especially for smallholders who have less access to chemical inputs (Bationo *et al.,* 2007; Saidou *et al.,* 2004). Improved fallows using agroforestry methods have improved soil organic carbon, contributing to better yields in many African countries (Vagen, Lal, and Singh 2005). Fallows in Zambia and Kenya, using fast growing, nitrogen-fixing leguminous trees, have improved soil moisture capacity.

Cotton cultivation in African countries is predominantly under rainfed conditions, as no irrigation schemes exist in many countries. Early sowing is highly recommended in order to avoid soil moisture stress during the cotton plant's reproductive growth stage, which would cause a decline in productivity. Many African countries have good rainfall but few water-harvesting and conservation systems that could enable supplemental irrigation for yield enhancement. The lack of development of irrigation potential has contributed to the low productivity of agricultural systems, food insecurity and high poverty rates (Nakawuka, 2017).

Cotton is a long-cycle crop in Africa. Early planting and retention of moisture during the critical crop growth period is vital for enhanced yields. Cotton extension specialists in Zambia estimate that cotton yields increased by about 100 kg/ha for each early week of planting (Grabowski *et al.,* 2014). Naudin *et al.,* (2010) conducted experiments on conservation agriculture techniques during 2001 and 2006 in Cameroon with no-tillage, and no-tillage combined with organic mulch. They concluded that no-tillage with organic mulching decreased yield by 16 kg/ha, with delays in sowing for each day. The reduction is less than that reported from 20 to 50 kg/ha per day when sowing was delayed under conventional tillage techniques. The same study also concluded that conservation agriculture experiments at field level showed potential benefits for smallholders.

Pest and Disease Management

Insects are a major threat to cotton. About 15% of the world cotton production is lost due to insect attacks every year (Oerke, 2005). In West Africa, the numbers are higher, with about 23% of cotton production lost to insects (Magicson *et al.,* 2013., Vognan *et al.,* 2002). The cotton bollworm complex causes significant damage to cotton in Africa. Amongst bollworms, the cotton Bollworm *Helicoverpa armigera* is the most damaging to cotton yields all across Africa. A greater proportion of insecticides used in cotton goes towards bollworm control.

For the past few decades, even after the introduction of GM crops, the pesticide consumption for crops has not decreased significantly in the developing world. Oerke (2005) mentioned that despite an increase in pesticide use all over the world, crop losses have not significantly decreased during the last 40 years. There is a great opportunity to promote IPM more effectively among resource-poor smallholders in Africa. Most crop protection research programmes are not oriented towards IPM but continue to focus primarily on chemical control (Agnes and Merman, 1991) or toward the need for *Bt*-cotton. Way and Van Emden (2000) conducted surveys and confirmed that there exists a vacuum in the area of IPM in the African region that needs to be filled with appropriate research in order to develop an effective, low-input, environmentally feasible and acceptable pest management approach that is appropriate for the resource-poor farmers and fits well within their practices of mixed cropping. Since smallholder cotton production is part of a mixed cropping system in Africa, IPM approaches in Africa require strong research that considers local cropping systems and institutional capacity-building programs and extension methods that educate farmers on the mixed-crop interaction effects.

The development of economic threshold-based pesticide interventions in several countries, particularly Mali and Cameroon, following the development of targeted pest and disease control programmes in Benin, demonstrates that it is possible to reduce the quantities of pesticides needed for effective crop production. A threshold-based insecticide spraying decision programme has been an important option in integrated pest management in cotton in Africa. The calendar-based programmes followed traditionally in Africa can circumvent the problems of any mistakes in pest identification or operation of the sampling procedures followed by farmers (Silvie *et al.,* 2001).

Under calendar-based intervention, cotton plants are protected during the entire period — from the start of flowering until the majority of bolls reach maturity — through insecticide applications that are scheduled on specified dates. But this method seldom worked because of the mismatch between pest infestation and the time when insecticides are sprayed. In the west African countries, though, threshold-based pesticide application has been initiated; adoption and expansion of this method remains slow due to insufficient knowledge of the growers, especially in identification of pests and natural enemies and assessing the level of economic threshold levels of the pest.

Several non-chemical methods of pest control have been tried in Africa including the development of resistant varieties, cultural control, agronomic practices and biological control. The hairy varieties developed for the control of jassids and aphids were found to be susceptible to whiteflies, which have been the major cotton pests in the West African region since the 1990s. The hairy cotton varieties greatly encouraged whitefly infestations, as the hairiness sheltered them against their natural enemies and insecticides (Ouola, 2008). Research on varietal development should need to focus on strategies that can enable the cultivars to tolerate all the major pests in the region.

Combining improved pest and soil fertility management practices shows promise for increasing yields in several countries of West Africa, apart from reducing the incidence of pests (Valerie *et al.,* 2011). Several studies found that:

- Deep ploughing destroys bollworm pupae;
- Hoeing helps to eliminate weeds that are potential host for pests,
- Early harvesting reduces sticky cotton, which is due to sugars produced by aphids and whiteflies; and
- Destruction of stubbles and crop-residues prevents pest carry-over.

Discussion

Research reviews point out that extensive socio-economic research is needed to understand the yield gap between the genetic potential of African cultivars and the low yields realised. In reality, it is unlikely that all the technologies would always succeed in all agro-ecological, socio-economic and political situations. However, many studies show that lack of political will and poor socio-economic conditions of farmers could be mainly responsible for low yields in Africa.

Since the colonial period and after independence, most African countries strived to improve the living standards of their people. The efforts may not have succeeded in alleviating poverty due to inefficient institutional setup along with exploitative nature of parastatal investors in the cotton sector. The lack of institutional support — either from government or from the private investors — in technology-transfer and adequate financial resources for research and technology adoption play a major role in yield stagnation.

There is no dearth of technologies developed locally in Africa or adoptable from other countries. However, most cotton technologies developed elsewhere in the world are input oriented and may not necessarily be suitable for the small-scale production systems of Africa. Many technologies that deal with nutrient management, water management, pest and disease management, or post-harvest management, require financial resources, which are scant in Africa. Cotton farming is less profitable in Africa mainly due to low yields and high input costs. The low yields and low income generated from cotton farming supports their bare minimum standards of living and does not enable farmers to invest more into agriculture.

Bt-cotton may be useful for effective bollworm control and insecticide reduction. But *Bt*-seeds would be expensive and farmers will have to invest more on seeds and supporting inputs for high yields. *Bt* cotton technology was adopted in Burkina Faso, South Africa and Sudan, as these countries have a well-established credit system for cotton. In eastern and southern Africa, where the cotton sector provides little credit to farmers, high seed costs may deter speedier adoption of *Bt*-cotton.

Valerie (2011) notes that given the constraints to widespread promotion of the *Bt*-cotton technology in Africa in the near future, it is encouraging to note that many of the soil, nutrient, water, and pest and disease management practices followed without any compromise in input applications, were found to have the potential to enhance the conventional cotton yields equivalent to *Bt*-cotton.

Since 2000, at least half of the world's fastest-growing economies have been in Africa, and as of 2012, the African countries with the highest agricultural value-addition (in terms of annual growth) included Burkina Faso, Ethiopia, Nigeria, Mali, Mozambique, Rwanda, and Tanzania (Landry Signe, 2018). With about 60% of the world's unused arable land, there is a lot of room for growth in Africa. Ample investment opportunities in agri-technologies such as fertilisers, machinery and irrigation systems could make Africa the major investment destination in the world.

Acknowledgements

The author thanks the Director, CICR and ICAR for approving the article to be presented at 14th SEACF network meeting at Harare, Zimbabwe. The author also thanks the ICAC for selecting this paper in the 'best paper category' submitted for the 14th SEACF network meeting.

References

Agnes Kiss and Frans Meerman. 1991. Integrated pest management and African agriculture. World Bank technical paper number 142.

Alain Renou, Idrissa Tereta and Mamoutou Togola. 2011. Manual topping decreases bollworm infestations in cotton cultivation in Mali. Crop Protection. 30:1370-1375.

Ashok Gulati and Surabhi Jain. 2011. Pricing crises in cotton, Discussion paper No.1. Commissioner for Agricultural and costs and prices, DAC Min of Agriculture, GOI

Badiane, O., Ghura, D., Goreux, L and Masson, P. 2002. Cotton sector strategies in West and Central Africa. World Bank Policy Research Working Paper 2867.

Baffes, J. 2007. The cotton problem in West and Central Africa: The case for domestic reforms. Econ. Dev. Bull. 11, 1–4.

Bationo, A., Kihara, J., Vanlauwe, B., Waswa, B and J. Kimetu. 2007. Soil Organic Carbon Dynamics, Functions, and Management in West African Agro-Ecosystems. Agricultural Systems 94: 13-25.

Bourgou, L and D. Sanfo. 2012. Potential Genetic Benefits of Using Brazilian Cotton Varieties to Improve those Cultivated in the C4 Countries: Analysis of Major Architectural and Agronomic Characteristics. Tropicultura, 2012, 30 (4): 243-248

Brazilian Cooperation Agency of the Ministry of External Relations. 2011. AID-FOR-TRADE: CASE STORY, WTO.

Charles, A.O., Midega, Isaac M. Nyangau, Jimmy Pittchar, Michael A. Birkett, John A. Pickett, Miguel Borges and Zeyaur R. Khan. 2012. Farmers' perceptions of cotton pests and their management in western Kenya. Crop Protection. 42:193-201.

Gergely, N and Poulton, C. 2009. Historical background and recent institutional evolution of African cotton sectors. In Tschirley, D., Poulton C and P. Labaste (Eds.), Organisation and Performance of Cotton Sectors in Africa: Learning from Reform Experience. World Bank, Washington, DC.

Haggblade, S and C. Plerhoples. 2010. Productivity Impact of Conservation Farming on Smallholder Cotton Farmers in Zambia. FSRP Working Paper No. 47. Lusaka, Zambia: Food Security Research Project.

Ilhem Baghdadli, Hela Cheikhrouhou and Gael Raballand. 2007. Strategies for Cotton in West and Central Africa: Enhancing Competitiveness in the "Cotton 4". World Bank Working Paper No. 108.

Isaacman, A. 1980. Cotton is the mother of poverty: Resistance to forced cotton production in Mozambique, 1938–1961. The International Journal of African Historical Studies. 13 (4): 581–615.

Ito, M., T. Matsumoto, T and Quinones, M. A. 2007. Conservation Tillage Practice in Sub-Saharan Africa: The Experience of Sasakawa Global 2000. Crop Protection. 26: 417-23.

Jianlong Dai and Hezhong Dong. 2014. Intensive cotton farming technologies in China: Achievements, challenges and countermeasures. Field Crops Research. 155:99–110.

Kranthi, K. R. 2015. Diagnosis holds the key to 'problem – solving' in cotton cultivation. Souvenir of the ICAC 74th Plenary meeting held at JW Marriot Mumbai 6-11 December 2015

Naudin, K., E. Goze, O., Balarabe, K. E., Giller and E. Scopel. 2010. Impact of no tillage and mulching practices on cotton production in North Cameroon: A multi-locational on-farm assessment. Soil & Tillage Research. 108: 68–76.

Landry Signe. 2018. Why Africa is Turning the Heads of Investors http: //africaneyereport.com/why-africa-is-turning-the-heads-of-investors/- accessed on 23:03:2018.

Magicson Mthembu, Cliff, S.. Dlamini and Banele Nkambule. 2013. The sustainability of cotton production using genetically modified seeds by emerging smallholder farmers in South Africa: a global and African perspective. African Journal of Agricultural Research. 8(32): 4293-4298.

Nakawuka, P. 2017. Global Food Security, http://dx.doi.org/10.1016/j.gfs.2017.10.003.

Narayanamoorthy, A and Kalamkar, S.S. 2006 – is Bt Cotton Cultivation Economically Viable for Indian Farmers? An Emprical Analysis, Economic and Political Weekly, June 30, 2006

Oerke, E. C. 2005. Crop losses to pests. J Agr Sci 144:31–43. doi:10.1017/S0021859605005708.

Ouattara, B. K., Ouattara, G., Serpantie, A., Mando and A. Sedego. 2006. Intensity Cultivation Induced Effects on Soil Organic Carbon Dynamic in the Western Cotton Area of Burkina Faso. Nutrient Cycling in Agroecosystems. 76 (2-3): 331-39.

Ouola Traore. 2008. Positive Developments in Integrated Pest Control for Cotton in West Africa. Improving Sustainability of Cotton Production in Africa. ICAC.

Philip, P., Grabowski, Steven Haggblade, Stephen Kabwe and Gelson Tembo. 2014. Minimum tillage adoption among commercial smallholder cotton farmers in Zambia, 2002 to 2011. Agricultural Systems. 131: 34–44.

Ripoche, Cretenet, Corbeels, Affholder, Naudin, Sissokoc, J. M., Douzet and P. Tittonell. 2015. Cotton as an entry point for soil fertility maintenance and food crop productivity in savannah agroecosystems–Evidence from a long-term experiment in southern Mali. Field Crops Research 177: 37–48.

Sabesh. M., Ramesh. M., Prakash. A. H and Bhaskaran, G. 2014. Is there any shift in cropping pattern in Maharashtra due to introduction of Bt Cotton, Cotton Research Journal, 6 (1): 63-70 http://www.cicr.org.in/isci/6-1/Paper_13.pdf.

Saidou, A., Kuyper, T. W., Kossou, D. K., Tosou, R and P. Richards. 2004. Sustainable Soil Fertility Management in Benin: Learning from Farmers. NJAS Wageningen. Journal of Life Sciences 52.3/4: 349-69.

Silvie, P., Deguine, J. P., Nibouche, S., Michel, B and Vaissayre. M. 2001. Potential of threshold-based interventions for cotton pest control by small farmers in West Africa. Crop Protection. 20: 297-301.

Tefft, J. 2010. White gold: Cotton in Francophone West Africa. In Haggblade, S and P. B. R. Hazell (Eds.), Successes in African agriculture: Lesson for the future. Baltimore: Johns Hopkins University Press.

Tschirley, D., Poulton, C and Labaste, P. (Eds) Organisation and Performance of Cotton Sectors in Africa: Learning from Reform Experience 2009. The International Bank for Reconstruction and Development - The World Bank.

Tschirley, D., B. Zulu and J. Shaffer. 2004. Cotton in Zambia: An assessment of Its Organisation, Performance, Current Policy Initiatives, and Challenges for the Future. MSU Working Paper No. 10. East Lansing: Michigan State University.

Vagen, T. G., Lal, R and B. R. Singh. 2005. Soil Carbon Sequestration in Sub-Saharan Africa: A Review. Land Degradation and Development. 16: 53-71.

Valerie Kelly, Duncan Boughton and Benjamin Magen. 2011. Pathways to Improved Profitability and Sustainability of Cotton Cultivation at Farm Level in Africa: An Approach to Addressing Critical Knowledge Gaps. MSU International Development Working Paper 112 February 2011.

Way, M. J and H.F. Van Emden. 2000. Integrated pest management in practice - pathways towards successful application. Crop Protection. 19, 81-103.