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The ICAC Recorder

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Cotton High Yields - This Time for Africa

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The ICAC Recorder

Editorial

'This time for Africa' is a powerful slogan. Africa has all of the natural resources that should have made it big for cotton. The continent is waiting for its time to come.

Three volumes of the special issues of the ICAC RECORDER have been dedicated to discussions on 'cotton high yields' in Africa. In the first two volumes, researchers agree that the challenges in Africa are tough, but all researchers have been unanimous that small steps can bring in a big change. Lessons from across the globe point out that cotton in Africa can win if the crop season, plant architecture and planting geometry are condensed to make the crop more efficient in using water, light and nutrients. I attempted to drive home these points in my article 'A change in plant architecture can break yield barriers in Africa' in the previous issue of the ICAC RECORDER, which has insightful articles by cotton researchers from Asia and Africa who described a wide spectrum of ideas to enhance yields and improve the cotton economy.

This sequel in the special series on 'cotton-high yields — this time for Africa' has four articles that continue to explore options for high yields and policies that can effect positive changes in the African cotton sector. Dr. Sabesh and Dr. Prakash are on a roll, at their insightful best. They examine the cotton-sectoral changes in Africa spanning 60 years since 1965. They look at Africa through a holistic prism while reviewing the technical and socio-economic dimensions to conclude that farmers deserve better prices and technologies for high yields while drawing attention towards the need for new investment enabling policies. Dr. Dong describes new 'light and simplified cultivation (LSC)' Chinese techniques that are applicable for the small-scale cotton farms in Africa. The LSC methods enable high yields of 1500 to 2000 kg per hectare at low production costs in China. Even at half their efficiency, the LSC techniques have the potential to double cotton yields in Africa. Dr. Blaise shares his expertise on conservation agriculture. He describes the technologies in a lucid manner to connect them with the farming systems in Africa. My article on 'the relevance of biotech cotton in Africa' deals with a brief description of the spectrum of biotech products and the current status and prospects for Africa.

Those who have been working for the betterment of cotton sector in Africa are familiar with the small-scale resource poor farmers, many of whom do not have access to fertilizers, pesticides, improved seeds and even the simplest of technologies due to poor purchasing power or weak logistics. Several researchers argue that without access to any of the technological inputs, yields in Africa cannot increase. In this context, it would be interesting to draw a parallel between Africa and India. India also has small scale resource poor farmers, but they have access to all the modern agri-technologies and inputs. However, yields in rainfed regions of India are as low as in Africa. For example, the Indian state of Maharashtra has an area of 4.2 million hectares which is equivalent to the cotton acreage in the whole of Africa, but the average lint yields at 350 kg/ha with a production of 1.5 million tonnes are strikingly similar. Cotton in Maharashtra is rainfed, very much like Africa. Further, Maharashtra has access not only to all agricultural inputs but has been growing the dual-gene Bt-cotton hybrids (not open pollinated varieties) in almost 95-98% of the area in the state. Therefore, it would be pertinent to ponder if the introduction of Bt-cotton, especially in the form of hybrids or emphasis on increased application of fertilisers and pesticide, would be great solutions to increase yields in Africa.

Researchers who have been batting for hybrids for high yields in Africa, must know that though hybrid cotton looks lucrative with big bolls and a promise of better quality and high yields over a longer duration, there are issues that need to be considered before taking the plunge. Cotton hybrid seeds are expensive; farmers cannot plant farm saved seeds; a hybrid cotton crop needs higher levels of water and chemical inputs; the plants have low harvest index due to higher biomass; due to the longer duration, the crop experiences severe moisture and nutrient stress in the post-monsoon phase during the critical boll formation window which causes yields and quality to plummet. Further the cotton season extends to such an extent that a second crop is rarely possible. It is interesting that except India and a few African countries which are characterized with low yields, major industrialized nations have rejected the hybrid technology, but have been getting 3 to 4-fold higher yields using open pollinated varieties, compared to India which has >95% of its cotton area under hybrid Bt-cotton and 38% under irrigation.

The discussions on Africa will continue in the future issues of the ICAC RECORDER. The ICAC will continue its technical efforts to explore tangible solutions to the intractable challenges in Africa and looks forward to collaborating with interested agencies for breaking the yield barriers and for the betterment of cotton farming systems and the entire cotton sector in Africa.

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The ICAC Recorder

Higher Cotton Productivity in Africa – A Socio Economic Analysis

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Agricultural systems are shaped primarily by technical and human interactions with natural and man-made resources. The technical factors are physical (soil, water, agrochemicals, etc.) and biological (seed varieties, insects, pathogens, etc.). These factors reflect availability in the natural environment and adoptions developed through technological interventions represented by irrigation, fertiliser and plant protection (Valerie *et al.,* 2011). Human interaction could be related to the socio-economic indicators including household size, income, land holding, poverty, health etc. Agriculture systems could be successful provided that both technical as well as human interactions and interventions are balanced appropriately for farm activities.

African agriculture is dominated by a variety of food crops and a few traditional cash crops including cotton. Cotton is a major source of foreign exchange earnings in more than 15 African countries and a source of cash income for poverty alleviation in these countries. African cotton farmers predominantly face three main constraints: very low cotton yield; very less price and forced reduction of cotton area due to production of food crops to support increasing populations. These factors make cotton cultivation less profitable in Africa. Main constraints in Africa are influenced by political, socio-economic and ecological conditions. The cotton production systems are subjected to vulnerability often due to policy decisions and changes enforced by the parastatal and internal authorities.

There was a significant shift in the cotton cultivation scenario in Africa during the past six decades. The cotton area shifted from eastern and southern African regions towards the western and central African region. Despite the fact that there is no dearth of cotton production technologies developed locally or adoptable from other countries in Africa, cotton yields have been low and stagnant for more than three decades. There is a need for an extensive socio-economic research and technical analysis to understand the reasons for the yield gaps to find solutions. Biotech cotton was introduced into Africa in Burkina-Faso, South Africa and Sudan. However, there has been no evidence of any significant yield enhancement in any of these countries, despite 6-18 years of adoption. This study attempts to analyse the key factors that influence yields and profitability in Africa.

Cotton Scenario in Africa

Cotton in Africa is predominantly a smallholder crop, mainly grown on small family farms of less than 3 to 4 hectares in size (Gouse *et al.,* 2003). Next to cocoa, cotton is a main source of cash income for millions of farmers and their families (Badiane *et al.,* 2002; Mosely and Gray, 2008) in more than 15 countries in Africa. Cotton in Africa is mostly rainfed, with exceptions of -South Africa where cotton is completely irrigated and countries such as Ethiopia, Nigeria, Kenya and Sudan, which provide irrigation in some farms. The rainfed conditions are coupled with vagaries of biotic and abiotic stresses and fluctuations in input costs and global cotton market prices. All these factors enhance risks and threaten the sustainability of cotton production in Africa.

During the period 1960 to 1980, Uganda, Egypt, Sudan, Mozambique, Tanzania and Chad were the major cotton growing countries. Though the area under cotton had been huge in these countries, the decadal growth rate was negative all through the period, in contrast to the positive growth rate in countries such as Burkina Faso, Mali, Benin, Ivory coast, and Zambia. During the 1990s cotton cultivation shifted towards Burkina Faso, Mali, Zimbabwe, Benin, Ivory Coast and to some extent in Chad (Figure 1). Thereafter, there was a significant shift in cotton cultivation domains from northern and eastern regions of Africa to the western region. Incidentally, many African countries implemented various reforms in cotton in the 1990s proposed by the Government and private investors. Intriguingly, all reforms failed to show any significant impact in the African countries. A critical analysis made by the authors indicates that reforms in agriculture should take stakeholders into confidence and more importantly should consider socio-economic and agro-ecological conditions of the implementation domains.

Until the late 1980s, countries such as Egypt, Sudan, Tanzania, Uganda and Zimbabwe were the major cotton producers. However during the past 17-18 years after 2000, Burkina Faso, Benin, Mali, Cote d'Ivoire, Cameroon and Zimbabwe emerged as top cotton producers due to adoption of new technologies and implementation of reforms in the agricultural sector. Remarkably, the annual average production in Burkina Faso was just about 42,000 Mt of cotton during the period 1965 to 2000, but between 2001 and 2017 the annual average production was 215,000 Mt, which made it the leading producer in Africa since 2013 (table 1). Likewise, Mali, Benin and Cote d'Ivoire also made notable progress in cotton production since the year 2000.

Cotton in Egypt is irrigated and productivity (yield) has been generally high. The productivity in Egypt was about 800 kg/ha for decades. Egypt cultivates only *G. barbadense* varieties under fully irrigated condition. In South Africa, the average cotton productivity was 360 kg/ha between 1965 and 1998 and the annual cotton acreage was about 110,000 hectares. *Bt*-cotton was introduced in the country in 1998 when the area was 137,000 hectares. Cotton area declined rapidly ever since to 23,000 hectares in 2004 when yields increased to 1,181 Kg/ha. By 2015, the area declined to 8,000 hectares, as yields increased to 1,208 kg/ha. Cotton area is increasing slightly in South Africa in recent years and was reported to reach 36,000 hectares in 2017. It is estimated that the area in Egypt, Sudan and South Africa declined by 60 to 75% in 17 years after 2000.

During the two decades between 1960s and 1980s, Egypt, Sudan, Uganda, and Tanzania were the leading exporters of cotton in Africa. However, subsequent to 1990, the western African countries gradually emerged as leading producers and major exporters. During the period 1965 to 2000, the annual exports by the west African countries (Burkina, Mali, Benin, Cote d'Ivoire and Cameroon) ranged from 34,000 to 71,000 tonnes. However the annual exports by the five countries increased to a range of 85,000 to 205,000 tonnes during 2000 to 2017, with Burkina and Mali in the lead. The annual average production in the five countries was 39,000 to 76,000 tonnes during 1965 to 2000, but increased significantly to 89,000 to 215,000 tonnes during 2000 to 2017, with highest production of 181,000 and 215,000 tonnes in Mali and Burkina Faso respectively.

During 1960s and 1970s cotton exports from the C4 countries (Mali, Burkina Faso, Chad and Benin) were 8% to 12%, which increased to 45% during the past three decades. Traditionally Egypt has been the highest cotton consuming country in the African continent, with an annual average consumption of 264,000 tonnes during 1970 to 2000 and 161,000 tonnes during 2000 to 2017. Countries such as South Africa, Nigeria, Ethiopia, and Tanzania have been utilising 30 to 40 tonnes of cotton annually over the 17 year period since 2000. South Africa imports cotton either from within Africa or from outside Africa for their domestic requirement. In recent years Egypt has also been importing cotton for their domestic consumption.

The high GDP rate in South Africa and Egypt combined with concomitant investment for cotton processing industries ensured the development of the textile sector to sustain the cotton economy in these countries. Except in Nigeria, cotton consumption in the west African countries has been low. Development of textile enabling policies and reforms for the development of textile industries will not only boost economy in the region but can also generate enormous employment opportunities.

The trends in C4 countries indicate significant changes in African cotton production. During 1960s and 1970s the average cotton area harvested in C4 countries was below 11% to 13% of the total cotton area harvested in Africa (Table 2). Prior to 1981, the production share of C4 countries

Table 1: Average Cotton Production, Export and Domestic Consumption in African Countries

	Production		Export		Domestic Consumption	
	1965-2000	2000-2017	1965-2000	2000-2017	1965-2000	2000-2017
Production appreciation countries (000 Metric Tons)						
Burkina	42	215	39	205	1	4
Mali	76	181	71	176	3	3
Benin	44	118	41	113	2	4
Cote d'Ivoire	69	120	54	114	14	6
Cameroon	39	89	34	85	5	3
Zimbabwe	67	87	47	77	19	14
Tanzania	59	80	47	48	12	29
Nigeria	43	64	7	30	51	42
Zambia	11	52	4	45	7	6
Togo	23	39	21	39	1	0
Ethiopia	19	33	2	4	20	31
Production sustainable countries (000 Metric Tons)						
Chad	50	50	48	47	2	1
Mozambique	23	27	19	27	4	0
Senegal	11	13	9	12	3	1
Production depreciation countries (000 Metric Tons)						
Egypt	401	169	156	75	252	162
Sudan	150	46	138	39	14	7
Uganda	27	24	23	21	4	2
South Africa	38	15	2	6	63	40

Compiled by the authors. Data Source: ICAC, 2018

Table 2: Percent Trends in Cotton Area, Production and Export in C4 Countries to Whole African countries

	1965-70	1971-80	1981-90	1991-2000	2001-10	2010-17
Area harvested						
C4	11.08	12.67	14.46	28.99	33.62	39.32
Benin	0.48	1	2.05	7.13	6.51	7.23
Burkina Faso	1.62	1.92	3.37	5.84	11.63	14.17
Mali	1.56	2.38	4.16	9.16	9.74	12.34
Chad	7.42	7.38	4.89	6.86	5.74	5.59
Production						
C4	6.25	9.75	14.89	30.2	36.51	41.84
Benin	0.5	1.01	2.23	7.98	8.26	7.9
Burkina Faso	0.69	1.42	3.59	6.1	13.6	16.98
Mali	1.14	3.14	5.5	11.35	11.18	13.86
Chad	3.93	4.18	3.57	4.78	3.48	3.1
Export						
C4	8.39	14.47	23.17	44.33	44.66	45.9
Benin	0.65	1.36	3.18	11.61	10.22	8.64
Burkina Faso	0.9	2.12	5.77	8.7	16.12	18.83
Mali	1.38	4.41	8.53	16.81	14.04	15.04
Chad	5.46	6.58	5.68	7.21	4.28	3.39

Compiled by authors; Data Source: ICAC, 2018.

Note: African Countries include Benin, Burkina Faso, Mali, Chad, Cameroon, Cote d'Ivoire, Egypt, Ethiopia, Kenya, Malawi, Mozambique, Nigeria, Senegal, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia, and Zimbabwe.

in Africa was less than 10.0% and the export share was less than 15%. However during 2010 to 2017 there was rapid all round growth in area, production and exports under cotton to reach an annual average of 39.3% of the area, 41.8% of production and 45.9% of the export share in Africa. The C4 countries grow cotton mainly under rainfed conditions in rotation with coarse grains predominantly in small holdings. Increase in the cotton acreage over the past two decades coupled with policy changes has resulted in increased production and exports thereby generating additional foreign exchange and fiscal revenues. At the farm level in Africa, earnings from cotton have been supporting financial investment in agricultural inputs, such as high-yielding seeds and fertilisers thereby generating increased cereal production, higher incomes, and farm asset accumulation among cotton-farming households (Tefft, 2010)

Nutrient and Irrigation management

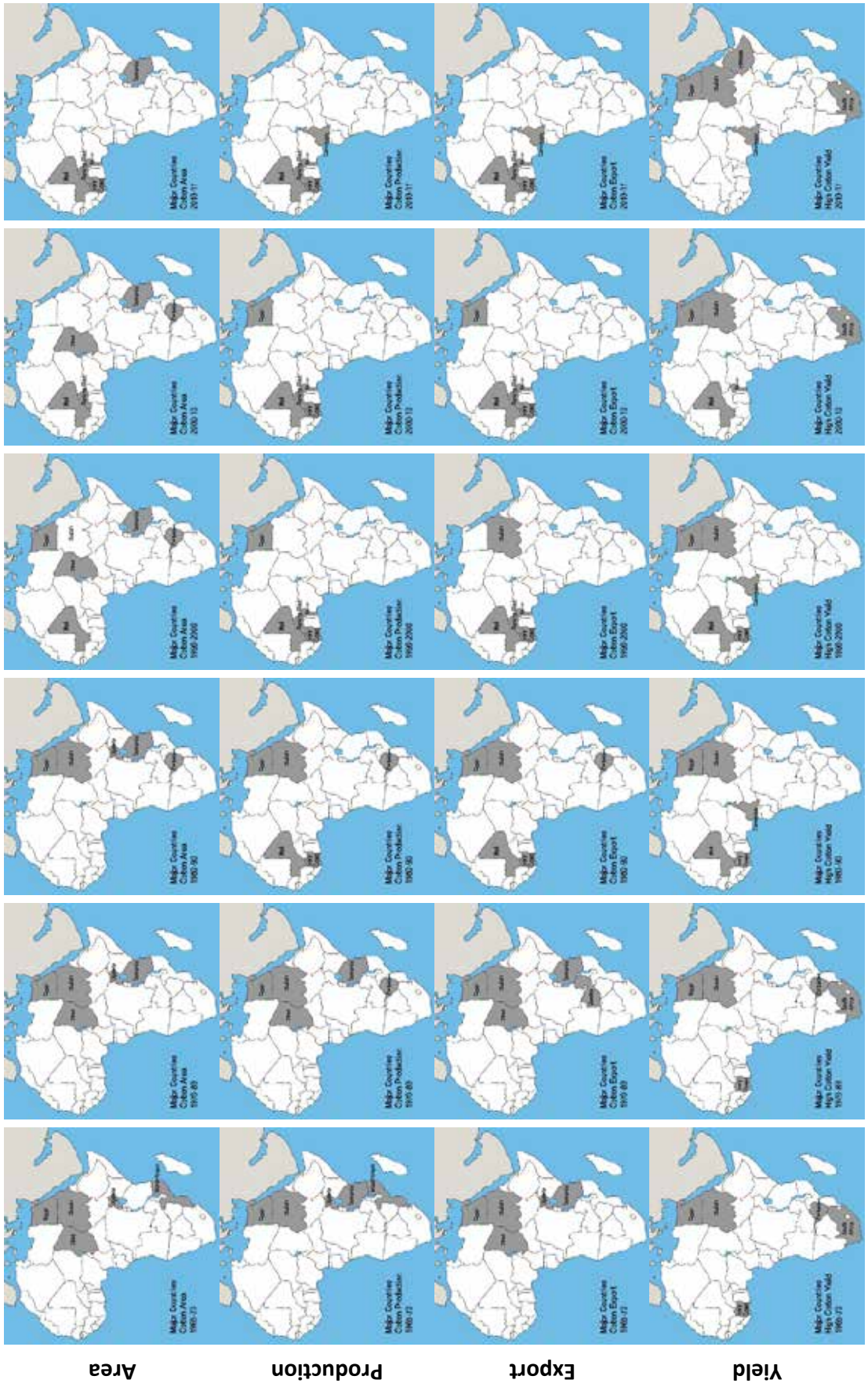
The current average fertiliser input in sub-Saharan Africa is just about 9.0 kg per hectare, compared to 100 kg to 135 kg in Asia, 73 kg in Latin America and 206 kg in the industrialised countries during 2016. Burkina Faso, which is the major cotton growing country of Africa, consumed on an average less than one kg/ha of fertiliser in 2001. It was only recently that fertiliser usage increased to reach 14.3 kg/ha in 2013 (Table 4C). In many African countries such as Benin, Uganda, Cameroon and Mozambique, the fertiliser input was below 10 kg/ha in 2013. Despite the low input of fertilisers and majority of the area under rainfed condition, the Crop Production Index (CPI) increased between 2001 and 2015 to the tune of 67%, 68%, 94%, and 106% in Benin, Burkina Faso, Mozambique and Cameroon, respectively (Table 4C).

Production and productivity barriers

The average yields in African countries vary significantly due to agro-ecological, technological advancement and socioeconomic factors. During 2001-02, in Benin, the northern region cotton yields out-performed the southern region by about 62% primarily due to the introduction of improved varieties and optimum input supply in the north. In Cameroon, agro-ecological factors linked to climatic and soil conditions contributed to the higher yield performance in northern region by about 125% than the southern region (Poulton et al. 2009). In Mali the difference in yield is about 15% higher in farms equipped with animal traction than manual cultivation, which lacked infrastructure. The general infrastructural development In Eastern and Southern African countries has been significantly less compared to the Western and Central African countries, especially in the late 1990s and early 2000s (Poulton *et al.,* 2009).

Studies were conducted in 2005-06 to assess the performance of different categories of farmers in seven African countries (Poulton et al. 2009). In the west African countries such as Burkina Faso, Mali and Cameroon, large farmers realised 25% and 65% more yield and gross revenue compared to medium and small farmers (Table 3). In southern and eastern African such as Mozambique, Tanzania, Uganda, Zambia and Zimbabwe, large farmers realised 65% and 184% more yield than medium and small farmers, respectively. The gross revenue earned by large farmers was 73% and 210% more than medium and small farmers, respectively in the southern and east African countries. The minimum difference in yields and gross revenue between large, medium and small farmers in west

Figure 1: Decadal Trend in Cotton Area, Production Export and Yield in African Countries



Prapared by authors from the data source ICAC, 2018

Table 3: Economics of cotton cultivation in Africa

Budget element	Burkina Faso	Cameroon	Mali	Mozambique	Tanzania	Uganda	Zambia	Zimbabwe
Large farmers								
Yield (kg/ha)	1,350	1,259	1,429	1,519	1,125	2,188	1,200	1,750
Seed cotton price (US$/kg)	0.33	0.32	0.32	0.21	0.28	0.25	0.25	0.31
Gross revenue (US$/kg)	441.45	399.1	452.99	322.03	314.06	547	300	542.5
Cost of input (US$/ha)	172.89	141.44	168.61	36.5	35.83	111.11	31.07	236.85
Cost of hired labour (US$/ha)	0	0	0	136.7	122.9	116.3	150.7	65.1
Net margin (US$/ha)	140.34	–1.86	156.24	91.93	71.16	137.55	56.16	173.82
Input cost/gross revenue	0.39	0.35	0.37	0.11	0.11	0.2	0.1	0.44
Medium Farmers								
Yield (kg/ha)	1,100	1,120	1,011	935	750	1,125	1,050	800
Seed cotton price (US$/kg)	0.33	0.32	0.32	0.21	0.26	0.25	0.25	0.29
Gross revenue (US$/kg)	359.7	355.04	320.49	198.22	196.88	281.25	262.5	232
Cost of input (US$/ha)	164.89	132.76	159.58	36	18	8.33	31.07	90.08
Cost of hired labour (US$/ha)	0	0	0	116.8	42.7	62.5	109.5	35.9
Net margin (US$/ha)	70.95	–4.32	51.29	–59.44	15.335	44.67	45.41	19.33
Input cost/gross revenue	0.46	0.37	0.5	0.18	0.09	0.03	0.12	0.39
Small Farmers								
Yield (kg/ha)	750	1,090	711	438	600	600	563	565
Seed cotton price (US$/kg)	0.33	0.32	0.32	0.24	0.24	0.25	0.25	0.21
Gross revenue (US$/kg)	245.25	345.53	225.39	103.91	144	150	140.75	119.78
Cost of input (US$/ha)	156.89	141.44	146.04	5.5	48.55	20.41	8.33	13.5
Cost of hired labour (US$/ha)	0	0	0	0	0	28.6	5.2	6.7
Net margin (US$/ha)	–62.06	–18.21	–0.19	2.37	–10.80	–58.91	–72.34	–41.78
Input cost/gross revenue	0.64	0.41	0.65	0.05	0.34	0.14	0.06	0.11

Source: Poulton *et al* . (2009)

Africa may be attributed to overall growth and uniformity in cultivation practices amongst all group of farmers.

There was not much variation in the cost of inputs in west African countries and on an average 46% of the gross revenue was spent on cost of inputs in all groups. On the contrary, the east and southern African countries spent just 16% of the gross revenue earned, except in Zimbabwe wherein the large farmers and medium farmers spent 44% and 39% of the gross revenue earnings respectively on inputs (Table 3). The average spending on inputs in west African countries was 153 US $/ha whereas it was 48 US $/ha in east and southern African countries. The cost of hired labour for cotton cultivation makes a lot of difference among African countries. In west African countries among all groups, the cost of hired labour is almost nil, which could be attributed to large adoption of farm equipped with animal traction for land preparation and inter-cultural operations (Kabwe & Tchirley, 2007). Poor adoption of farm equipment in east and southern countries, also reveals that the large and medium farmers spend almost 33% of their gross income on hired labour (Table 3). Small scale farm mechanisation in east and southern Africa can enable the countries to divert the investment on hired labour towards inputs as in the west African countries.

According to the ICAC, the average yield in west African countries between 2000 and 2017 was 379 kg/ha, while it was only 218 kg/ha in east and southern African countries. The yield differences in west African and east and southern African countries have been attributed to the better willingness and ability of the west African monopoly systems to invest in varietal development, input supply and credit, quality extension services, and logistical support. The major investments made in west African countries before 2000 are most likely to have been responsible for the yield differences amongst regions (Kabwe & Tchirley, 2007, Valerie *et al.,* 2011).

Cotton Pests and Diseases

Cotton yields and fibre quality are damaged by a wide range of insect pests and diseases. Since the 1980s, insecticide use on cotton crops in west African countries reduced considerably, largely due to the development of control methods based on pest monitoring. In most of the African countries, chemical control of pests depends on two methods: treatments applied according to a predetermined calendar, or insecticide applications triggered by the degree of infestation or extent of damage (CIRAD, 2012).

Numerous plant protection techniques have been tried in African countries. In Mali, hairy leaf cotton varieties were introduced to reduce jassid infestation. However, the hairy

varieties provide cover to whitefly larvae to escape from predators (Ouola, 2008). Cotton bollworms *H. armigera*, *Earias spp.,* and *D. watersi* cause serious economic damage in west Africa. In Mali and other west African countries, de-topping of cotton plant at the peak flowering period was introduced to reduce bollworm infestation. De-topping in China restricts plant growth, induces earliness and enables proper partitioning of photosynthates to increase yields (Dai and Dong, 2014). However, de-topping did not enhance yields, but only contributed to the reduction in bollworm damage in Mali (Renou *et al.,* 2011). In Africa, pest management can become efficient with short-season compact-architecture varieties that are planted in high densities (Kranthi, 2016, 2018).

Integrated Pest Management (IPM) is a multidisciplinary decision support system in coordination with pest observation and degree of infestation for the selection and use of pest control strategies, based on economic threshold levels that consider the interests and impacts on producers and the environment (Josian Edson et, al., 2013, Bajwa and Kogan, 2002). According to a World Bank report (Credit 610-IN, Report No. 7863), under the ICDP project in India, pest scouting system helped in reducing the number of sprays undertaken by the farmers and yield increased from 469 kg per ha in 1976-77 to 651 kg in 1981-82. IPM practices have also been successful in Sudan and Egypt. In Sudan, IPM practices in cotton resulted in more than 50 percent reduction of insecticide use (Pretty, 1995) and 70% reduction in pesticide applications (Russell, 1997).

In Africa, *Bt*-cotton was introduced for commercial cultivation in 1998 in South Africa (Gouse *et al.,* 2004), in 2009 in Burkina Faso and in 2012 in Sudan (James, 2014). Nigeria, Ethiopia and Swaziland approved Bt-cotton for commercial cultivation in 2018. The cotton bollworm *Helicoverpa armigera* is a major pest in west Africa that can cause up to 90% damage if neglected (Vitale and Greenplate, 2014). In the year 2013, the yield of *Bt*-cotton was 14% higher than that of conventional cotton in Burkina Faso but production costs were equivalent to that of conventional cotton (Pertry et al. 2016). *Bt*-cotton hybrids in India are input intensive and well suited for irrigated condition, and not all *Bt*-cotton varieties are equally suitable for all climatic conditions (Sabesh[a] *et al.,* 2014 and Narayanamoorthy, 2006). Mayee and Bhagirath (2013) found in their survey that just 24% of the Maharashtra (India) farmers considered *Bt*-cotton yield as major benefit from adoption of Bt cotton - where 96% of cotton grown under rainfed conditions. However, the *Bt*-cotton growers gained additional net income of 65% more than the conventional cotton growers due to yield gain. The benefits of *Bt*-cotton, in Burkina Faso, are viewed based on the reduction in insecticide applications caused due to the efficacy of the *Bt*-gene in controlling bollworms. The significant reduction of insecticide use from six sprays during the 3-4 months of growth phase in conventional cotton to two sprays applied at the end of the growth phase has proved to be the main incentive for adoption of *Bt*-cotton by many cotton growers (Karembu *et al.,* 2014).

The Burkina Faso government announced a ban on *Bt*-cotton from 2018 citing quality deterioration as the main reason. Cotton producers estimated their losses between 2011 and 2016 at around $82 million (Deutsche Welle, 2016). The report also mentioned that Burkina Faso's decision to abandon genetically modified cotton is unlikely to have much impact in South Africa, Egypt and Sudan. Biotech-cotton trials are underway in Malawi, Kenya, Uganda, Nigeria and Ghana. Agricultural technologies undergo rigorous evaluation for specific agro-ecological conditions, but erroneous adoption and compromise on cultivation practices can diminish their value (Sabesh[b] *et al.,* 2014).

Social Aspects in African Cotton Sector

There are many diseases plaguing human health in African countries. Diseases such as malaria, HIV and more recently Ebola infections threaten the livelihood and economy of millions of Africans. According to the World Health Organisation (WHO), African countries carry 25% of the world's disease burden but their share of global health expenditure is less than 1%. In 2001, African countries agreed to allocate at least 15% of their budgets to health care, but until 2016-17 only six countries (Botswana, Burkina Faso, Malawi, Niger, Rwanda and Zambia) met this commitment. Malaria and HIV levy a heavy economic burden on many African economies. It is estimated that over one million people die from malaria each year, mostly children under five years of age, with 90 per cent of malaria cases occurring in Sub-Saharan Africa (UNICEF). An estimated 300-600 million people suffer from malaria each year. Malaria infections were huge in all the cotton growing countries of Africa. The infection ranged from 158 to 516 out of 1000 people in the year 2000 (Table 4A). But, due to the serious attention paid by the Governments to eradicate of the infection, the numbers were reduced to less than 300 out of 1000 people in the year 2016. Nevertheless, the problem is still serious in Mali where the infection rates are high. In addition, out of more than 30 million HIV patients in the world about 70% are in sub-Saharan Africa. According to a WHO report among HIV infected people in the world, six out of ten men, eight out of ten women, and nine out of ten children are in Africa. The number of HIV infections per 1,000 uninfected population from all sex and age groups, ranged from 0.55 to 11.71 out of 1000 people in the year 2000. Due to the intervention of international agencies, HIV infections were significantly reduced to less than five per 1000 people in the year 2016.

According to the World Health Organisation, one out of 12 children in Africa dies before the age of five, and about 430 women die each day from avertible causes related to pregnancy and childbirth. Pneumonia, the major disease among children remains prevalent in some of the poorest

Table 4A: Socio economic indicators of African countries

		Maternal mortality ratio per 100,000 live births	Under-five mortality rate per 1,000	Under Nourishment (%)	Below Poverty (%)	HIV infections per 1,000	Malaria incidence per 1,000	Access to electricity (%)
Burkina Faso								
	2000	341	75.9	15	25.95	0.55	158.11	77.62
	2010	246	51.7	12.1	13.5	0.33	118.74	83.52
	2016	216	42.5	10.8	8.99	0.3	93.95	85.34
Benin								
	2000	572	144.7	23.9	47.48	1.05	388.77	20.58
	2010	446	111.6	12.1	40.18	0.48	331.63	34.2
	2016	405	99.5	7.5	28.2	0.4	293.68	34.1
Chad								
	2000	1,370	190.2	40.1	67.87	2.64	241.5	2.94
	2010	1,040	160.1	41	27.5	0.97	193.87	6.4
	2016	856	138.7	34.4	18.03	0.63	163.16	8.02
Mali								
	2000	834	219.6	13.9	74.78	0.79	476.81	10.37
	2010	630	136.6	5	47.08	0.67	364.72	22.34
	2016	587	114.7	5	45.13	0.62	448.61	27.29
Zimbabwe								
	2000	590	105.8	43.7	53.77	11.71	143.17	33.05
	2010	446	89.5	34.7	64.59	7.15	129.61	35.6
	2016	443	70.7	33.4	62.74	4.95	114.19	32.3
Uganda								
	2000	620	148.4	28.4	57.53	3.51	516.78	8.38
	2010	420	75.2	25.1	30.32	4.38	429.05	13.18
	2016	343	54.6	25.5	18.73	2.45	218.26	20.4
Cameroon								
	2000	750	150.4	32.3	25.5	3.59	461.06	41
	2010	676	104.8	13.4	23.41	2.31	321.85	52.91
	2016	596	87.9	9.9	15.46	1.98	264.2	56.8
Mozambique								
	2000	915	171.1	42	81.83	7.76	515.63	6.95
	2010	619	102.8	31.8	66.14	6.4	383.3	17.03
	2016	489	78.5	25.3	52.97	3.58	297.72	21.22

Source: SDG Indicators, Global Database, United Nations Statistics Division

Note: Below poverty: Proportion of employed population above 25 years age and below the international poverty line of US$1.90 per day (the working poor) ; HIV infection: Number of HIV infections per 1,000 uninfected population from all sex and age group; Under nourishment: Prevalence of undernourishment all age group both sex (%); Access to electricity: Proportion of population with access to electricity all age group both sex (%); Malaria incidence: Malaria incidence all age group both sex per 1,000 population; Maternal mortality: Maternal mortality ratio both sex per 100,000 live births.

regions in Africa because of unaffordable expensive vaccines necessary to prevent it. According to World Health Organisation, in 2015 pneumonia killed nearly one million children under the age of five, accounting for 15% of global deaths of children of that age group in Africa. The mortality rate of children in African countries below the age of five ranged from 75 to 219 per 1000 in the year 2000. However, due to policy interventions and Government support, mortality reduced from 42 to 138 per 1000 in the year 2016 (Table 4A). The other health concerns in Africa are maternal mortality ratio and undernourishment. Adequate attention enabled significant reduction in maternal mortality and undernourishment during the past one and half decades

Basic amenities such as access to electricity, safe drinking water services and safely managed sanitation services are still lacking in many parts of Africa. Other issues such as, food insecurity, unemployed population above 25 years age and population below the international poverty line of US$1.90 per day are major concerns that need attention. Poverty (below the international poverty line) ranged from 25 to 81% in the year 2000, which declined to 8 to 62 % in the year 2016 (Table 4A). A critical analysis points out that countries such as Zimbabwe, Mozambique and Mali need to pay more attention for poverty eradication. According to Clarence and Quentin (2007), in 2003, poverty among cotton producers in Benin, Burkina Faso, Chad and Mali, was 53.3, 47.2. 72.7 and 77.8% respectively which was high compared to the poverty among general population of these countries at 39.0, 46.4, 55.0, and 47.4% respectively. The data indicate that cotton producers in Africa are, on an average more likely to be poor than the general population as a whole. However in Burkina Faso, the difference in poverty among cotton producers and general population was minimum. The differences in estimates of the share of the population in poverty between cotton producers and the population as a whole are very large in Benin, Chad, and more prominently in Mali.

According to the World Bank data, the average life expectancy at birth was 48 years in African countries from 1990 to 2000, which increased to 60 years in 2016. Over the past decade, investment on health care was more compared to investment on measures that support household income. Population growth in Africa was at 46% from 2000 to 2015, whereas it was 1.9% in Europe, 18% in Asia and 20% globally. Population growth rate was more than 50% in cotton growing countries of sub-Saharan Africa except Zimbabwe (Table 4C). However 5.5% increase in agricultural labour with a concomitant reduction in the country's rural population was recorded in Mali (Table 4C). The growth in population affects cotton production as land is diverted towards cultivation of food crops.

Table 4B: Socio economic indicator of African countries

	Average Household size	Average children	Female Headship (%)	Share of Household below 15 years children (%)
Burkina Faso	5.7	3.4	10	83
Benin	5	3.1	23	78
Chad	5.8	3.7	22	84
Mali	5.7	3.4	9	87
Zimbabwe	4.1	2.4	41	73
Uganda	4.7	3.3	30	79
Cameroon	5.2	3.2	23	71
Mozambique	4.4	2.7	36	77
Ivory Coast	5.4	3	18	73
Ethiopia	4.6	2.7	26	79
Kenya	3.9	2.6	32	66
Swaziland	4.7	3	48	66

Source: United Nation Data (2017)

Table 4C: Socio economic indicator of African countries

	Rural Population (%)	Value Added	Crop Production Index	Fertiliser consumption	Agriculture labour (%)@	Population
Burkina Faso						
2001	81.5	388.9	84.2	*0.4	^84.7	11945
2010	74.3	422.9	120.7	9.4	80.8	15605
2015	70.1	388.7	**141.6	**14.3	^^80.0	18111
Benin						
2001	61.4	827.7	89	*16.4	^46.1	7077
2010	58.1	989.9	116.2	9	45.3	9199
2015	56.1	1150.8	**149.1	**5.5	^^43.2	10576
Chad						
2001	78.3	NA	91.5	NA	^76.7	8663
2010	78	1869.1	100.8	NA	78	11887
2015	77.6	2096.6	**116.0	NA	^^76.6	14009
Mali						
2001	70.9	671	91	NA	^51.2	11293
2010	64	1156.4	137.8	19.6	58.9	15075
2015	60.9	1731.3	**138.6	**27.9	^^56.7	17468
Zimbabwe						
2001	65.8	894.9	141	*35.7	^70.1	12366
2010	66.8	371.1	99.6	34.1	68.4	14086
2015	67.6	422.2	**108.2	**36.8	^^67.5	15777
Uganda						
2001	87.8	499.7	98.9	*1.3	^73.7	24855
2010	85.5	480.2	109.4	1.7	73.7	33915
2015	83.9	473	**107.9	**2.2	^^72.1	40145
Cameroon						
2001	53.9	1012.9	78.3	*9.8	^64.1	15672
2010	48.5	1434.1	144.6	9.2	63.7	19970
2015	45.6	1786.8	**161.2	**6.7	^^61.8	22835
Mozambique						
2001	70.7	205.1	84.5	*6.0	^76.4	18589
2010	69	320.1	157.8	8.2	75.5	24221
2015	67.8	339.5	**163.7	**9.3	^^75.0	28011
Ivory Coast						
2001	55.8		93.8	*31.0	^60.9	17040
2010	49.4	2169.2	106.5	32.1	60.3	20401
2015	45.8	2795.9	**123.6	**36.1	^^56.0	23108

Source: World Bank – World Development Indicators (2017); @: United Nation Data (2017)

Note: Value addition: Agriculture value added per worker (constant 2010 US $); Crop Production Index: Crop Production Index (2004-2006=1000); Fertiliser consumption: Fertiliser consumption kg/ha of arable land; *: pertains to 2002; **: pertains to 2013; ^: pertains to 2005; ^^: pertains to 2017.

Urbanisation has been taking place rapidly in many key zones of Africa. The highest rate of 58% urbanisation was found in Congo -the major exporter of oil in Africa. Urbanisation was about 50% to 52% in the Iron and mineral ore exporter zone of Mauritania and in the gold and diamond exporter, South Africa. In oil exporting countries such as Gabon and Cameroon, urbanisation was 49% and 44% respectively till 1994 (Porter, 1995). Rural Africa had 70% of its population in 2001, which reduced to 63% in 2017. Rural populations in Africa depend completely on agriculture for livelihood. During the period 2001 to 2015, there was 10% decrease in the rural populations in Burkina Faso, Mali and Ivory Coast (Table 4C). It is speculated that the migration could be due to migration to towns in search of livelihood, because the small-holdings were inadequate to support their minimum standard of living.

Most of the African countries have a household size of an average of 5 children with more than 75% of the households having children of less than 15 years of age (table 4B). The percentage of females heading a family was more (32%) in southern and eastern African countries as compared to the west African countries (16%). To state that this could be a reason for slow and/or non adoption of improved technologies in cotton cultivation is only a speculation. By 2025, African countries would be filled with a huge working population in the world. An increase in working population seems good as long as there is adequate planning, with appropriate policy decisions to channel energies or else it could induce more poverty in Africa. It is important that the large working population in Africa is utilised properly, especially in agriculture and more so in the cotton sector, where cotton is one of the main crops that has immense potential to provide employment, livelihood and cash-flow to sustain the economy of most African countries.

The Numbers Game

Table 5 has been reproduced from Vitale et al (2011) who compared cotton production of Burkina Faso with Oklahoma in the united States. The survey concluded that on an average, the US cotton farmers incur significantly higher production costs - both variable and fixed costs than Burkina Faso farmers. The US cotton producers realised higher returns as price of cotton per kg was US$ 0.55, whereas it was US$ 0.35 in Burkina Faso (Table 5). Data were examined for remunerative returns for Burkina Faso farmers by either price or by yield escalation. Three scenarios were explored for price escalation (price escalation by 0.01, 0.02, and 0.03 US$ per kg) and three scenarios for yield escalation (yield escalation by 20%, 40%, 60% over and above the survey yield). Under yield escalation scenario, If the Burkina Faso farmers increased the yield by 10% with associated cost escalation for variable costs they would obtain additional income of US$ 42 per farm; with 40% and 60% yield escalation they would obtain an additional revenue of US $ 84 and UD$ 123 per farm, respectively. With a price escalation scenario, an increase of US$ 0.01 per Kg farmers would fetch an additional UD$39 per farm; and for an escalation of US$ 0.02 US and US$ 0.03 per kg farmers would obtain additional revenues of US$ 77 and US $ 116 per farm respectively.

The study points out that a small increase in cotton prices can more than compensate yield enhancement. It is for the Governments to decide whether to focus on increasing the cotton prices or on measures to increase the yields. The returns for cotton farmers are identical with every cent increased in the cotton price which is equivalent to 20% yield increase (figure 2). In order to increase yields, farmers may be required to increase inputs such as fertilisers, insecticides, herbicides, fungicides and associated labour costs. In this process of moving towards higher productivity, the Burkina Faso farmers may incur additional variable costs apart from contributing to increased pollution, soil degradation and resource wastage. While the importance of yield enhancement cannot be undermined, the study points out that in the current socio-economic situation of cotton cultivation in Africa, a small increase in cotton prices of one or two cents per kg can offset the efforts to produce more. Therefore, sustainable cotton production and poverty alleviation in Africa could be achieved by a small increase in cotton prices for remunerative returns while focus continues to increase yields and reduce input costs.

Discussion

- The present study summarises the status thus far and suggests the way forward for sustainable cotton cultivation in Africa
- There is a significant shift in the intensity of cotton cultivation from eastern and southern African region to western and central African countries in the recent past. This may be attributed to conducive social, economic reforms in west African countries that caused significant changes in the cotton cultivation patterns in Africa.
- There is a need to reassess and bring about adequate structural changes by means of reforms for soil nutrient management programmes in African countries.
- There is a need to encourage and empower the small holders in east and southern African countries to provide optimal input supplies for cotton cultivation.
- There is a need for adoption of farm equipment, depending on the scarcity of the labours in different zones to ensure enhanced remuneration for small holders. Community farm equipment sharing programmes may be created at an affordable cost for small holders.
- There is a need for varietal improvement programmes embracing local varieties which are environmentally suitable for different agro-ecological conditions of different parts of Africa.

Figure 2: Relationship of Price Escalation (US$ per Kg) with Yield Enhancement

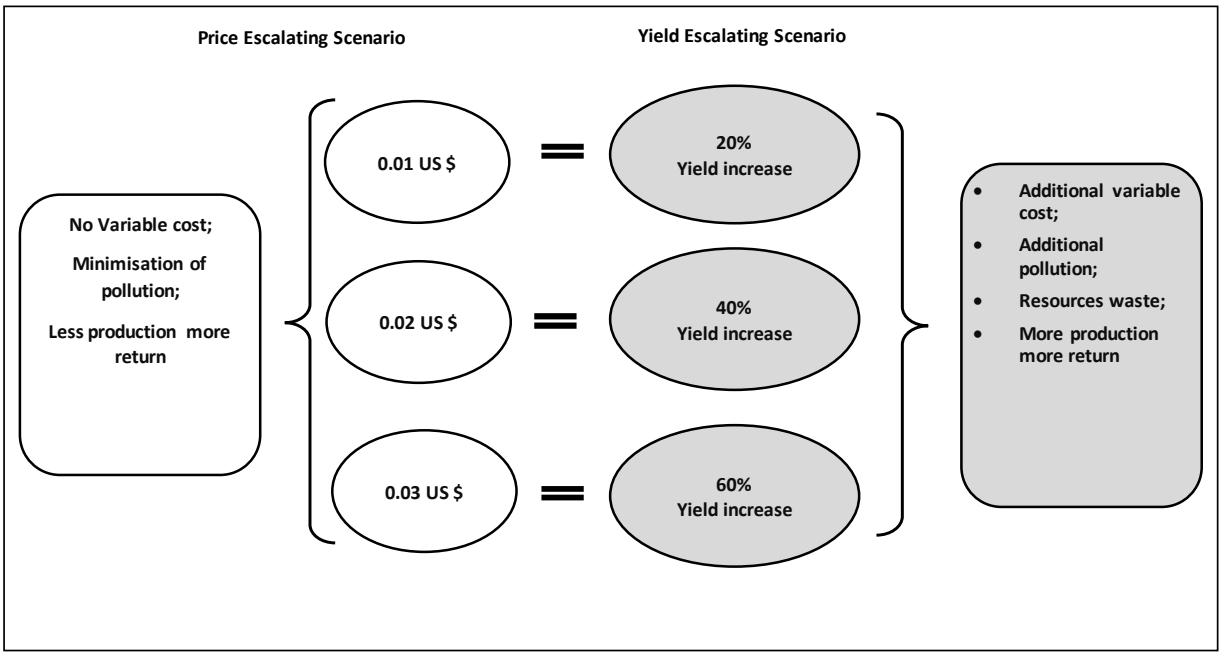


Table 5: Comparison of cotton production costs in Oklahoma (US) and Burkina Faso (West Africa)

	Actual as per survey		Scenario for Price Escalation US$/kg in Burkina Faso			Scenario for yield Escalation in Burkina Faso		
	Oklahoma	Burkina	0.01	0.02	0.03	20%	40%	60%
Price US$/kg	0.55	0.35	**0.36**	**0.37**	**0.38**	0.35	0.35	0.35
Yield kg/ha	2437	1050	1050	1050	1050	**1260**	**1470**	**1680**
Gross Revenue US$/ha	1340	367	378	388.5	399	441	514.5	588
Variable cost	1131	311	311	311	311	373	435	498
Implements	151	32	32	32	32	32	32	32
Total	1282	343	343	343	343	405	467	530
Net Revenue US$/ha	58.35	24.5	35	45.5	56	36	47.5	58
Farm size (ha)	504	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Total farm revenue US$	29408	**91**	**130**	**168**	**207**	**133.2**	**175.75**	**214.6**
Production Cost US $/kg	0.46	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Source: Vitale *et al.* 2011

- Biotech cotton for insect resistant traits could play an important role in African countries that are plagued by bollworm damage.
- There is a need to inculcate the use of efficient plant protection strategies and input supply management, especially through trainings on need based plant production and protection interventions.
- Investment on education, employment opportunities and healthcare with focus on eradicating malaria and HIV, must receive high priority.
- Population growth rate needs to be curbed, if economy has to be stabilised.
- There is a need for intensive planning so as to formulate policy decisions for proper utilisation of the huge working population that would be available by 2025.
- Increase in cotton prices can effectively enhance remuneration and net returns.
- There is a need to develop strategies that can enhance yields through low input usage

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