Greener Journal of Agricultural Sciences
Vol. 9(2), pp. 163-170, 2019
ISSN: 2276-7770

DOI Link: http://doi.org/10.15580/GJAS.2019.2.040619064
http://gjournals.org/GJAS

Cotton production potential areas, production trends, research status, gaps and future directions of cotton improvement in Ethiopia

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ARTICLE INFO

Article No.: *040619064*
***Type*:** *Review*
DOI: *10.15580/GJAS.2019.2.040619064*

Submitted: *06/04/2019*
Accepted: *11/04/2019*
Published: *25/04/2019*

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Keywords: *Bt cotton; CFTs; improved varieties; potential; transgenic cotton*

ABSTRACT

Cotton is one of the main cash crops in Ethiopia and is widely grown in the lowlands on large-scale and small-scale farms under both irrigation schemes and rain-fed agriculture. There are about more than 3 million hectares of potential land suitable for cotton production in the country. However, out of the country's total potential areas for cotton production, only about less than three percent is being utilized yet. So, the current domestic cotton production is much lower than the potential. But, cotton consumption in Ethiopia is outstripped domestic cotton production due to the demands of the rapidly expanding textile industry in the country. Thus, Ethiopia has been importing raw cotton from abroad. Cotton production and productivity is highly constrained by a lot of biotic, abiotic, social and economic factors. For the last five decades the Ethiopian Institute of Agricultural Research/EIAR/ and Werer Agricultural Research Center/WARC/ has made the utmost effort and several improved cotton technologies were released; such as improved varieties along with proper crop management and crop protection practices. Since, transgenic cotton has been proved in controlling the major insect pests in global cotton production, Ethiopia recently started Bt cotton adaptation trial after getting approval for CFTs by the regulatory authority in the country to overcome the constraints of bollworms in the cotton production and two genetically modified cotton hybrids were recommended for commercial production. Despite the huge research efforts made, the production and productivity of the crop was not attained its maximum potential as a result of low utilization of the research recommended technologies by cotton producer farmers and low utilization of resource potential lands. There are several factors contributed for the low acceptance, underutilization and/or adaptation of the improved cotton technologies. Therefore, there is a huge gap ahead to fill in technology development, research capacity building and creating effective research, extension and stakeholders linkage. In this paper, potential areas, production trends, gaps, research status and future directions for cotton improvements were assessed in order to plan well-organized research strategies for the future.

INTRODUCTION

Cotton is the most essential natural fiber crop in the world for textile produce, accounting for about 50% of all fibers used in the textile industry. It is more important than the various synthetic fibers, and it is grown all over the world in about 80 countries (Acquaah, 2007). Cotton is unique among agricultural crops, because it is the main natural fiber crop, and also provides edible oil and seed by-products for livestock feed, it also provides income for hundreds of millions of people (Chaudhry and Guitchounts, 2003). Cotton is one of the agro-industrial crops which are produced in both developing and developed countries. Cotton fibers are used in clothing and household furnishings (Goreux, 2003). It has played an important role since the industrial revolution of the 17th century. Currently, it is an important cash crop especially for a number of developing countries at local and national levels (Baffes, 2004).

Cotton is the most important cash crop in Ethiopia and plays a vital role in the agricultural and industrial development of the country's economy. Cotton provides basic raw materials (cotton fiber) to the textile industry for domestic market or for export. Besides its fiber, cotton provides seed, which is an important source of rich protein and oil for human and animal consumption. At the household level, cotton is an important cash crop for the small holder farmers nationwide, and it generates income to rural household food security, especially to the peasant subsistence farmers in Ethiopia. Moreover, cotton provides livelihood to hundreds of thousands of people engaged in farming, processing, trade and marketing. Cotton is both an important export and import substitute commodity crop and as an export crop, it is an important foreign currency earner and as an important substitute crop, it serves as an important item to save the country's earning and thus the contribution of the cotton crop to the overall growth of national economy is immense.

Cotton is widely grown in the lowlands under large-scale irrigation schemes and on small-scale farms under rain-fed agriculture in Ethiopia (EIA, 2012). Cotton is primarily grown as fibre crop. In Ethiopia, a good cotton yield is obtainable from areas varying in altitude from sea level to about 1000 masl (EIA, 2012). The Omo-Ghibe, Wabi Shebele, Awash, Baro-Akobo, Blue Nile, and Tekeze river basins have been identified as major potential cotton growing areas in Ethiopia (Alebel Bayrau *et al*., 2014).

Ethiopia has a very good cotton-growing condition and a large amount of land potentially suitable for cotton production (Alebel Bayrau *et al*., 2014). However, out of the country's total potential areas for cotton production, only about three percent is being utilized currently. As a result, the amount of cotton produced in the country is small and the current domestic cotton production is much lower than the potential (Bosena Tegene *et al*., 2011).

Werer Agricultural Research Center (WARC) was established under the umbrella of the Ethiopian Institute of Agricultural Research (EIAR), to coordinate national cotton research program in Ethiopia. Various studies have been conducted by WARC/EIAR on cotton research under different disciplines. About 34 convectional varieties have been released by WARC/EIAR since 1960s up to 2015 through introduction, adaptation and collection as well as hybridization of lines for generating recombinants, followed commonly by pedigree selection. Out of these varieties, about 29 varieties have been released for irrigated areas, whereas 05 varieties have been released for rain-fed based cotton production areas. In addition to convectional varieties, since among cotton production constraints, Bollworms are the major constraints and they cause about 36- 60% yield loss in severe infestations (Ababu, 1986) at Ethiopian conditions. So, Ethiopia started Bt cotton adaptation trial under confined field during 2017 cropping season and depending on the results, 2 hybrid Bt cotton varieties are recommended for commercial production.

Insect pests of cotton are a key restriction to production because of the large yield losses and quality degradation they cause. To manage cotton pests, a number of entomological research works have been conducted since the establishment of WARC. The yield potential of cotton mainly depends on its appropriate management practices. So, various number of agronomical research practices have been done by WARC to increase cotton production, productivity and fiber quality through developing appropriate cotton management practices and cropping system for different cotton growing agro ecologies. For the last five decades, WARC/EIAR is not only generating improved cotton technologies, but also in collaboration with various partners multiplying and disseminating improved cotton technologies to end users, a lot has been done so far and greatly contributed for the development of cotton sectors in the country.

WARC/EIAR has been making a maximum effort to the development of the country's agricultural sector through generating several improved cotton technologies by different research disciplines since its establishment. Despite the large amount of improved cotton technologies generated, most of them were underutilized by farmers. Moreover, the research efforts made so far to develop high yielding varieties with better fibre qualities through the utilization of hybridization methods and selection technique from existing stocks was also not successful in part because of the limited availability of cotton germplasm materials, and partly due to the negative correlation between yield and quality of cotton in addition to the absence of instrumentation at the research center for measuring fiber quality properties made the research attempts to develop varieties which can allow the production of cotton with acceptable quality and quantity.

In general, research on cotton follows a multidisciplinary team approach to tackle the various production problems. Research project components include variety development; crop management (fertility and irrigation); pest management (entomology, plant pathology and weed management), socio economic research; technology multiplication and promotion.

Potential areas for cotton production in Ethiopia

Ethiopia has a long practice of cotton cultivation. Majority of the cotton cultivation takes place in the Awash Valley, Gambela, Humera, and Metema. Cotton has grown in many of the regions in the country. In each region, there are wide potential areas: in Tigray 269130ha, in Amhara 678,710 ha, in South nations, nationalities and people region (SNNPR) 600,900 ha, in Oromia 407420 ha, Gambella 316,450 ha, Benshangul 303,170ha, Afar 200,000 ha and Somali 225,000ha. Most of the areas are low land and at river basins (EIA, 2012). A report in 2010 from the then Ministry of Agriculture (MoA) indicates that there is about more than 3 million hectares of potential land suitable for cotton production in the country. On the contrary, current area covered by cotton crop in Ethiopia is estimated to be only about 100,000 hectares, out of this, 60, 000ha is commercially irrigated and 40,000ha is small scale, from which 70% rain-fed and 30% irrigated, (SOFERCO scoping study, 2016 unpublished).

Production trends and gaps

However, out of the country‘s total potential areas for cotton production, only about less than three percent is being utilized currently. As a result, the amount of cotton produced in the country is small (Bosena Tegene *et al*., 2011) and the current domestic cotton production is much lower than the potential which poses as a constraint with respect to poor integration of the country‘s textile and garment industries, limited use of pesticides and chemical fertilizers by Ethiopian smallholder farmers (EIA, 2012). The areas coverage and the amount of seed cotton production have been fluctuating (Figure 1) because, Farmers are shifting from cotton production to high-value crops such as sesame, sugarcane, etc. because of poor productivity and low market price for seed cotton or discouraging price difference between the three (A, B and C grades) quality standards of cotton lint. But, Cotton consumption in Ethiopia is outstripped domestic cotton production due to the demands of the rapidly expanding textile industry. Thus, Ethiopia has been importing cotton from abroad (USA, China and India). For instance, according to ICAC (2016) report, Ethiopia imported cotton lint that amounted to 11,000 and 13,000 Mt during 2014/15 and 2015/16 respectively and about 50 and 60 thousands of bales during 2017/18 and 2018/19 respectively (Table 1).

As pointed out earlier, Ethiopia has a considerable potential for growing cotton not only in terms of suitability of the existing ecological settings but also a number of other factors including favorable policy, economic, socio-cultural, technological and environmental perspectives. As part of the external environmental factors assessment, it is also a logical exercise to examine the potentials of cotton in the country which can and should be exploited by drawing lessons from other countries that have advanced levels of research and development achievements in cotton production-productivity.

Cotton lint is the main raw material needed for the production of garments and will be sourced from ginneries and traders. Accordingly, comparisons, in terms of production and lint cotton yield productivity were made between the statuses that the national cotton production and productivity is found in currently and that of the world average and those of top cotton producing countries with comparable environmental settings and the highest records which is for the purpose of benchmarks (Table 2). It is very clear from Table 2 that the gap between what has been achieved so far by the National Cotton Research program and the potential promise is wide for cotton production-productivity and key quality variables in Ethiopia. This available potential can, therefore, be considered as one of the stimuli to even augment research efforts in a bid to maximize productivities thereby contributing to the overall volume of production to satisfy the textile industries increasing demand in Ethiopia.

Table 1. Cotton Supply and Distribution (1,000 HA and 1000 480-lb. Bales) in Ethiopia

Country	Year	Area Harvested	Production	Imports	Total supply	Use	Exports	Ending stocks
Ethiopia	2018/19	65	175	60	328	240	0	88
	2017/18	60	175	50	323	230	0	93

Source: USDA, 2018

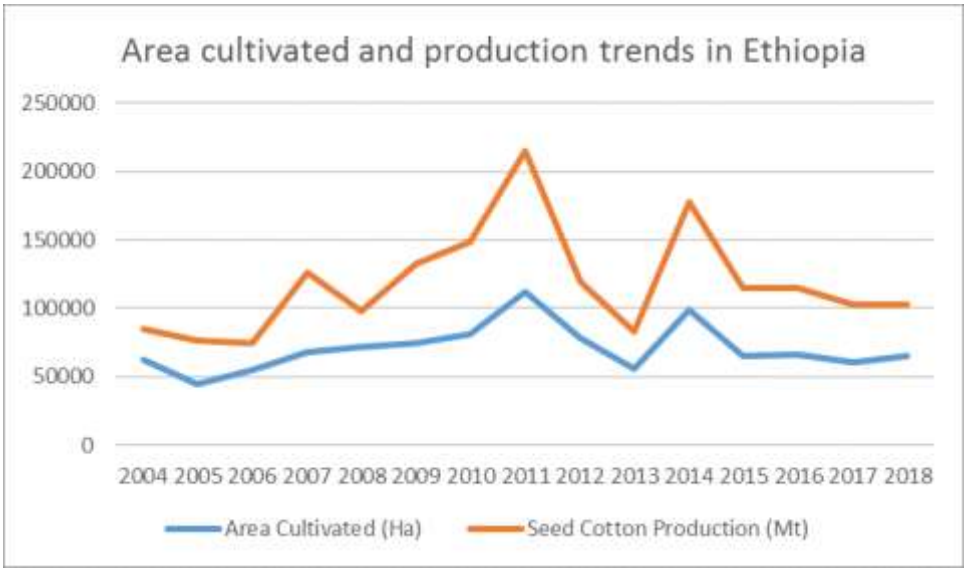

Figure 1. Cotton area cultivated and production trends in Ethiopia

Table 2. Comparing average cotton production and productivity of Ethiopia with top cotton producing countries and World average.

Country		Area (Million hectares)			Yield (Kilograms per hectare)			Production (Million 480 lb. bales)		
		2016/17	2017/18	2018/19	2016/17	2017/18	2018/19	2016/17	2017/18	2018/19
1	India	10.85	12.40	12.40	542	509	483	27.00	29.00	27.50
2	United States	3.85	4.49	4.20	972	1,014	964	17.17	20.92	18.59
3	China	2.90	3.40	3.35	1,708	1,761	1,755	22.75	27.50	27.00
4	Pakistan	2.50	2.70	2.40	671	661	671	7.70	8.20	7.40
5	Brazil	0.94	1.18	1.40	1,626	1,708	1,711	7.02	9.22	11.00
6	Uzbekistan	1.18	1.25	1.20	687	672	599	3.73	3.86	3.30
7	Turkmenistan	0.55	0.55	0.55	529	535	399	1.33	1.34	1.00
8	Australia	0.58	0.53	0.30	1,520	1,931	1,814	4.05	4.70	2.50
9	Turkey	0.40	0.47	0.52	1,742	1,853	1,800	3.20	4.00	4.30
10	Burkina	0.70	0.85	0.75	407	333	406	1.31	1.30	1.40
11	Mali	0.66	0.73	0.74	412	403	412	1.24	1.35	1.40
12	Greece	0.21	0.23	0.25	1,071	1,174	1,200	1.03	1.24	1.35
13	Ethiopia	0.066	0.060	0.065	642	635	586.20	0.195	0.175	0.175
	World	29.81	33.56	33.27	779	803	777	106.66	123.70	118.74

Source: USDA, 2018

Major past research efforts and achievements

Cotton is an important source of cash for the growers and an important input for textile factories, cottage industries and oil mills. The cotton industry evolved from home-yard cultivation into modern state and private farms, and from cottage weaving into modern spinning and weaving mills. In order to satisfy the growing demands of cotton from time to time, research on cotton was established in 1966 at Melka Werer (now Werer), one of the potential areas in the Middle Awash Valley. WARC was established under the umbrella of the EIAR, to coordinate national cotton research program in Ethiopia. For the last five decades, WARC has made the utmost effort and several improved cotton technologies were released. The early years of cotton research focused mainly at improving the yield of cotton as the needs of the expanding textile mills was for quantity rather than quality. Consequently, it was possible to develop varieties that gave remarkable seed cotton yield of 3 - 5 t/ha under research condition. Over the past four decades, based on their yield performances 19 improved varieties were identified and recommended and/or released to producers.

In recent years, ginners and spinners have become quality conscious and demand for better quality.

Hence, increased pressure is being placed on cotton breeders to develop cultivars that meet the requirements of growers for high yield potential and the demands of the textile industry for improved fiber quality.

Varietal development

Starting from its establishment, Werer Agricultural Research Center was mandated for developing genotypes that are suitable for different agro-ecologies to meet the demands of farmers and the textile industries across the country by employing conventional breeding methods. To date, 22 varieties and 7 hybrids were released for irrigated areas and 5 varieties for rain-fed areas based on their merits of seed cotton yield and fiber quality characteristics. A total of 34 convectional varieties have been released by the cotton research department as shown below in Table1. These varieties have been released depending on ranking mean performances of genotypes at individual locations and overall mean performances of genotypes methods through introduction and adaptation and as well as hybridization of lines for generating recombinants, followed commonly by pedigree selection. Since cotton is predominantly self-pollinated, but up to about 30% sometimes higher cross-pollination occurs (Acquaah, 2007), hybridization of lines for generating recombinants, followed commonly by pedigree selection to identify superior genotypes is the most common breeding procedure that has been used by WARC. The cotton research team currently is dealing with the acquisition of more varieties and testing for their adaptation and evaluating them with more emphasis on fiber quality parameters. Moreover, as cotton is more liable to pests, management practices to control them and improved agronomic practices are the core research agenda for the cotton research team. In addition to convectional varieties, since among cotton production constraints, insect pests of cotton are a major constraint to production because of the large amount of yield losses and quality degradation they cause, Ethiopia started Bt cotton adaptation trial under confined field during 2017 cropping season and depending on the results, 2 hybrid Bt cotton varieties are recommended for commercial production in 2018.

Among these varieties, some of them weren't used by producers because, some of the varieties had become obsolete because of replacements by another varieties, some of them are hybrids which were recommended through introduction and adaptation and because of their high seed price, producers didn't import seed and produce and some of the varieties were not popularized or promoted to producers as well. Therefore, currently a small number of varieties are under production in the country.

Table 1. Cotton varieties released by Werer Agricultural research Center (WARC) for production since 1966.

No.	Variety name	Released year	Seed cotton yield kg/ha	Ginning percent (GOT%)	Micronaire	Fiber length mm	Fiber strength lb/sq inch	Recommended for
1	A-333-57	1960s	2930	34.6		-	-	rain-fed
2	Acala 1517/70	1975	3890	36.7		-	-	Irrigated
3	Albar 637	1960s	2060	34.8		-	-	Rain-fed
4	Acala 1517C	Before 1970	-	37.2		-	-	Irrigated
5	Acala 1517D	Before 1968	-	-		-	-	irrigated
6	AMS1(70)	1974	2590	37.6		-	-	irrigated
7	Werer 1-84	1984	2860	37.8		-	-	irrigated
8	La Okra Leaf 2	1986	2730	38.0		-	-	irrigated
9	Acala 4.42	1974	2350	38.6		-	-	irrigated
10	Reba B-50	1960s	1800	36.3		-	-	Rain-fed
11	Acala SJ2	1986	3250	34.2	3.2	28.6	79.3	Irrigated
12	Arba	1987	3000	40.1	3.5	30.2	79.7	Rain-fed
13	Bulk 202	1989	3340	41.0	3.5	28.1	78.3	Rain-fed
14	Deltapine 90	1989	3860	34.8	3.7	27.7	77.3	Irrigated
15	Cucurova 1518	1994	4170	38.9	3.8	26.9	74.6	Irrigated
16	Cu-Okra	1994	3760	38.9	4.0	26.1	75.7	Irrigated
17	Carolina queen	1994	4180	39.6	3.8	27.2	77.6	Irrigated
18	Sille-91	1997	3860	39.4	3.6	27.9	72.7	Irrigated

No.	Variety name	Released year	Seed cotton yield kg/ha	Ginning percent (GOT%)	Micronaire	Fiber length mm	Fiber strength g/tex	Recommended for
19	Stam59A	2007	3340	42.0	4.3	29.8	32.5	Irrigated
20	Ionia	2008	2890	38.7	4.2	30.0	31.4	Irrigated
21	YD-206	2011	4200	37.2	3.5	34.4	36.5	Irrigated
22	YD-223	2011	4130	37.5	3.4	33.8	36.6	Irrigated
23	YD_211	2011	4220	35.9	3.3	34.2	36.6	Irrigated
24	YD-670	2013	4000	37.1	3.5	32.0	34.8	Irrigated
25	YD-195	2013	3370	39.2	3.5	31.7	35.2	Irrigated
26	VBCHB 1203	2013	2470	36.6	4.46	30.7	32.2	Irrigated
27	VBCH 1527	2013	2430	29.0	3.6	29.9	34.0	Irrigated
28	STG-14	2014	3880	42.7	4.22	30.0	31.7	Irrigated
29	Candia	2014	4060	44.1	4.1	29.0	30.20	Irrigated
30	Claudia	2014	3840	45.7	4.36	30.9	32.4	Irrigated
31	Gloria	2014	4260	43.0	4.1	29.4	31.96	Irrigated
32	WARC-CC1	2015	4070	44.8	4.3	28.8	25.9	Irrigated
33	WARC-AC2	2015	4300	39.0	3.9	27.7	29.5	Irrigated
34	WARC-GU3	2015	4620	38.2	3.9	26.1	29.5	Irrigated
35	JKCH 1947 (Bt cotton)	2018	3056.2	39.4	4.06	27.78	27.75	Irrigated
36	JKCH 1050 (Bt cotton)	2018	3049.6	39.2	3.95	28.44	28.59	Irrigated

Source: (MOARD, 2009, 2014, 2018 and WARC Progress Report, 2014, 2015, 2018 Unpublished)

But, cotton research in Ethiopia is still conventional. It needs some modernizing specially breeding system, such as using marker assisted selection technology, Enhanced breeding system, breeding cycle, breeding for long staple cotton, breeding varieties suitable for mechanical harvesting, breeding for drought tolerant varieties, transgenic cotton, Genomic studies, Resistance breeding, Hybrid technologies, Mutation breeding, Breeding for Colored Cotton, etc.

Crop Management

Yield potential of the cotton crop largely depends on management practices from land preparation to harvesting. Research and demonstration efforts have been made to implement several recommendations on proper cultural practices such as land and seedbed preparation, time of sowing, seeding rate and spacing, irrigation system, fertilizer rate, weed management, use of cotton defoliant and cotton growth regulator, proper time of harvesting and post-harvest handling system to ensure increased cotton production and productivity in the country.

Cotton Pest Management Research

The cotton plant protection research activity was mainly undertaken with full responsibility of Werer Agricultural Research Center under three major research disciplines namely; cotton entomology, and pathology and weed science research with the objective of contributing for the enhancement of cotton production and productivity through adoption, generation and promotion of effective cotton pest management technologies and information in the sector.

Cotton Entomology Research

Pests recorded: Based on the field survey conducted from 1986/87 to 1995/96, more than 60 insect and 2 mite species were recorded on cotton and their status was categorized as major, minor, rare and sporadic pests of cotton in Ethiopia. Results of surveys indicated that the African bollworm (ABW) (*Helicoverpa armigera*), aphid (*Aphis gossypii*), leaf worm (*Spodoptera litoralis*), pink bollworm (*Pectinophora gossypiella*), jassid *(Empoasca lybica*), whitefly (*Bemisia tabaci*) and thrips (*Thrips tabaci*) were recorded as key pests (Tsedeke, 1982 and Ermias *et al*, 2009).

Basic studies

Several basic studies such as: Population dynamics for bollworms, armyworms and whitefly, Diapauses behavior studies of the African and pink bollworms, Host range of cotton whitefly (*Bemisiatabaci*), Detection of Insecticide resistance for ABW and cotton aphid were made and the findings were documented as base line information for planning further management studies. Different management methods of these insect pests are also recommended so far for the producers.

Constraints for Cotton Research in Ethiopia

Germplasm Enhancement

- Lack of large number of germplasms (Limited germplasm resources)
- Narrow genetic bases for different traits of interest at researchers hands
- Lack of varieties that combine high yielding ability with good quality characters
- Lack of hybrid cotton varieties suitable to different production systems & agro-ecologies
- Lack of long and extra- long cotton germplasms (Gossypium bardadense/ Egyptian cotton)
- Shortage of varieties for rain fed cotton growing areas
- Lack of varieties resistance/tolerant to biotic (diseases and pests) and abiotic (salinity, drought and temperature) stress
- Lack of cotton varieties suitable for mechanical harvesting
- Lack of plant biotechnology research to assist conventional cotton breeding

Limited capacity (human, facility and financial) at the research center

There is no interest from donors to support cotton research financially and technologically; since cotton is considered as a cash crop/ government interest crop. Therefore, its research is fully supported by the limited public money. Moreover, the crop is grown and researched in harsh environment; there is high turnover of skilled manpower in the research system.

Lack of cotton seed production, supply and delivery system

Cotton seed for planting has always been a constraint. Limited quantitative and qualitative seed cotton production in Ethiopia is the limited availability and poor quality of planting seeds (cotton seed) provided to seed cotton producers. Seed is not available in the required quality and quantity. In Ethiopia, there is no cotton seed production, processing, and delivery mechanism except the services provided by Werer Agricultural Research Center (WARC) (parent seeds and commercial seeds on a limited scale) and the informal seed channel provided by some private commercial farms, private seed companies, private traders, ginneries and smallholder farmers.

Weak cotton research-extension (RE) linkage system

The extension system is highly devoted for the promotion of food crops and the cotton sector is highly neglected. Most small scale cotton farmers use unimproved varieties, low inputs and poor management practices resulting in low productivity and poor quality lint. Compared to other major crops, extension service on cotton development has been discouragingly low.

Biotic and abiotic stress factors

Insect pests of cotton are a major constraint to production because of the significant yield losses and quality degradation they cause. Bollworms cause about 36- 60% yield loss and on irrigated cotton production, about 22% and 14% of seed cotton yield loss can be caused by sucking pests and cotton aphid, respectively (Ababu, 1986). Climate change is becoming a threat as a cause for emergence of new pests such as mealy bug. Also a dynamic shift of some minor pests such as white fly, thrips and spider mites to major pests in the cotton ecosystem is a big concern. Unrestricted spread of these pests is highly challenging to cotton production and requires the attention of the research system. On the other hand, cotton grown in drought prone areas will be subjected to the effects of climate change and expanding of salinity problem is the abiotic constraints.

Future research directions

Breeding for Long Staple Cotton varieties

At present, 100% of cotton in Ethiopia falls in medium long which fulfills the requirement of the domestic industry. The major constraint to develop extra-long staple is limitation of *Gossypium barbadense* germplasm in the country. But, breeders are making efforts to develop extra-long cotton varieties from existing germplasm.

Developing varieties suitable for mechanical harvesting

Since the start of large scale commercial farming in Ethiopia in the 1970s, a great stride has been made in area expansion and cotton production in the country. As a result, cotton production showed rapid advancement from manual cultivation and production to semi-mechanized farming. Cotton harvesting, however, remain unchanged and is still practiced by hand picking. Nowadays it is not uncommon to see the fully matured cotton crop remain for an extended period of time exposed to the sun, dust, and weathering and many other varying environmental factors and this may continue for some time to come. Nevertheless, some private investors are suffering from acute shortage of labor during harvesting time and currently they are requesting for improved and, or potential promising varieties that are adaptable to mechanical harvesting. So, breeders planned to develop varieties suitable for mechanical harvesting in a short time.

Breeding of abiotic tolerant varieties

Salinity and water scarcity is the major issue not only in Ethiopia but also in the world. The research on

salinity and drought resistant/tolerant and low water requirement varieties need to be developed for efficient utilization of irrigation water and for the solution of expanding of salinity problem.

Hybrid Cotton

Increase in yield and quality is possible through exploitation of hybrid vigor. Research on development of cotton hybrids is the regular feature of Werer Agricultural Research Center (WARC).

Transgenic Cotton

Transgenic cotton has been proved not only in controlling the insect pests, particularly of bollworms but also is environmental friendly. Adaptation of Bt cotton will reduce the use of pesticide and ultimately reduction in cost of production and increase in the profit of the farmers. Intensive research is needed to develop local transgenic cotton plant for commercial cultivation in the country. Biotechnology Department in Holeta Agriculture research Center (HARC) is trying to get permission for conducting research on genetically modified cotton. In collaboration with this Department, the Bt genes will be transferred to locally commercial varieties.

Breeding for Coloured Cotton

Coloured cotton of brown, dark brown, light brown and light green colours will be developed.

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Cite this Article: Bedane G; Arkebe GE (2019). Cotton production potential areas, production trends, research status, gaps and future directions of cotton improvement in Ethiopia. Greener Journal of Agricultural Sciences 9(2): 163-170, http://doi.org/10.15580/GJAS.2019.2.040619064.